THE MOTIVATIONAL EFFECT OF NEED ON DECISION-MAKING UNDER RISK

SANDEEP MISHRA
B.Sc. (Hon.) (Psychology), McMaster University (2005)
M.Sc. (Psychology), University of Lethbridge (2007)

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DEDICATION

To my parents, who taught me the value of education from a very young age and sacrificed so much for me to get here. This accomplishment is as much yours as it is mine.

ABSTRACT

Risk-sensitivity theory predicts that decision-makers shift from risk-aversion to risk-preference in situations where low-risk options are unlikely to meet their needs. Risk-sensitive theory is contrasted with more traditional unbounded models of decision-making predicting that decision-makers seek to optimize utility in all decisions. In this dissertation, I review influential theories of decision-making from the various behavioral sciences, and offer an integrated approach to understanding decision-making informed by evolutionary theory. I then present evidence suggesting that risk-taking comprises a general phenomenon, inclusive of such behaviors as gambling and antisocial conduct. Finally, I demonstrate in several laboratory experiments that conditions of need, such as inequality, are important motivators of risky behavior. Together, the results suggest that risk-taking represents a functional triggering of preference for variable outcomes in response to conditions of need, consistent with risk-sensitivity theory.

PREFACE

All of the experiments reported in this dissertation underwent review (and were approved) by an institutional human ethics research board. All participants were carefully and fully debriefed after each experiment as to the purpose, hypotheses, and implications of each.

Several of the chapters in this dissertation were published in peer-reviewed journals and were written with co-authors. Below, I indicate which chapters were published elsewhere and describe the contributions of my co-authors. To avoid undue duplication, a single references list is provided at the end of the dissertation that includes references for all of the individual chapters.

Chapter three consists of a manuscript that is in press at *Personality and Individual Differences*. Martin Lalumière was co-author, and provided conceptual, methodological, and editorial assistance.

Chapter four consists of a manuscript that was published in *Personality and Individual Differences*. Martin Lalumière and Robert Williams were co-authors, and provided conceptual and editorial assistance.

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Chapters one and six consist of manuscripts that were submitted for publication. Martin Lalumière was co-author on both, and provided conceptual and editorial assistance.

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Mishra, S., & Lalumière, M. L. (2010). You can't always get what you want: The motivational effect of need on risk-sensitive decision-making. *Journal of Experimental Social Psychology*, *46*, 605–611.

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CHAPTER ONE

Introduction

Why do people engage in risky behavior? Risk-taking typically brings to mind thoughts of irrational, reckless, or even pathological behavior. Yet, almost everybody engages in risk-taking to some degree. Are there circumstances under which risk-taking is beneficial? The research reported in this dissertation is concerned with answering these and other questions; broadly, the research presented here seeks to examine how various environmental and social cues interact with personal characteristics to facilitate risky behavior.

The Study of Decision-Making Under Risk

Risk-taking has been traditionally considered reckless and impulsive behavior (e.g., Eysenck, Pearson, Easting, & Allsopp, 1985; Gottfredson & Hirschi, 1990; Zuckerman, 1994). Implicit in this definition is the assumption that engaging in risky behavior is irrational or pathological, in that it is counter to an actor's best interests. It is possible, however, to define risk-taking in a less pejorative manner. Economists and biologists generally define risk as outcome variance, where the riskier of two options with the same expected value is that with higher outcome variance (Daly & Wilson, 2001). This broader conceptualization of risk includes such behaviors as crime and gambling, in that both involve high variability in outcomes. For example, property theft is a high variance behavior: Potential outcomes include gain of resources, injury, or incarceration. Similarly, gambling is a high variance behavior because it involves the possibility of outcomes ranging from a large gain to a large loss.

In the first section of this dissertation (Chapter Two), I elucidate an integrated theoretical framework for understanding decision-making under risk. I accomplish this by first reviewing several of the most influential theoretical frameworks that have been used to explain patterns of decision-making under risk in various disciplines: Expected utility theory (economics), prospect theory and heuristic approaches (psychology), and risk-sensitivity theory (biology). Second, I review several robust empirical findings that any integrated, comprehensive theory of decision-making must explain, such as age and sex differences in risk-taking, individual differences, and the role of emotion and cognition. I suggest that a broadly relevant theory for understanding decision-making under risk should integrate elements of expected utility theory, prospect theory, and risk-sensitivity theory using an ecologically relevant, evolutionarily-informed normative approach.

The Generality of Risk

Substantial evidence suggests that various forms of risky behavior, including crime, substance use, risky driving, early sexual intercourse, sexual coercion, gambling, and antisocial behavior tend to co-occur both within individuals and at the aggregate level (e.g., Bartusch, Lynam, Moffitt, & Silva, 1997; Donovan & Jessor, 1985; Hirschi & Gottfredson, 1994, Leblanc & Girard, 1997; Lussier, LeBlanc, & Proulx, 2005; Mishra & Lalumière, 2009; Mishra, Lalumière, Morgan, & Williams, 2010; Mishra, Lalumière, & Williams, 2010; Osgood, Johnston, O'Malley, & Bachman, 1988). Furthermore, individuals who regularly engage in various forms of risk-taking (including gambling and crime) score higher than others on measures of poor self-control, impulsivity, and sensation-seeking (reviewed in Zuckerman, 2007).

In the second section of this dissertation (Chapters Three and Four), I examine (1) the degree to which various measures of risk-propensity are associated, and (2) the degree to which risky behavior is a general phenomenon inclusive of such behaviors as gambling and antisocial conduct. Much previous research has artificially parsed various forms of risk-taking (e.g., crime, gambling, general thrill-seeking). However, these various forms of risky behavior all involve variability in outcome, and may thus represent different manifestations of an underlying propensity for risk. Chapter Three examines the relationship between personality traits (measured through self-report) and behavioral preferences for risk. Chapter Four examines whether gambling behavior is a form of risk-taking. The results of the studies presented in Chapters Three and Four suggest that (1) personality traits and a behavioral preference for risk are highly associated, and (2) various measures of risk, including gambling, appear to be part of a general preference for risk. Together, these results indicate that risky behavior is a general phenomenon.

The Motivational Effect of Need on Risky Behavior

Animals, including humans, are generally risk-averse, preferring low variance options over high variance options (reviewed in Kacelnik & Bateson, 1996, 1997; Weber, Shafir, & Blais, 2004). Risk-sensitivity theory, however, predicts that decision-makers shift from risk-aversion to risk-preference in situations of high need, where need refers to disparity between an individual's present state and goal (or desired) state (Mishra & Lalumière, 2010). Risk-sensitivity theory posits that animals, including humans, do not necessarily seek to maximize or optimize certain outcomes (e.g., maximizing number of calories consumed, or dollars earned), but rather, primarily seek to minimize the probability of experiencing outcomes that fail to meet one's needs in important domains (e.g., avoiding death, or excessive debt; Rode, Cosmides, Hell, & Tooby, 1999; Stephens, 1981; Stephens & Krebs, 1986).

Risk-sensitivity theory was originally conceived to explain decision-making in foraging circumstances in non-human animals (Caraco, Martindale, & Whittam, 1980). However, almost every human and non-human decision is made under some condition of need: If someone is at distance from an acceptable threshold (e.g., low income, poor social status) they may do well to engage in risky behavior to improve their situation (Wilson & Daly, 1997).

In the third section of this dissertation (Chapters Five and Six), I examine whether risk-sensitivity theory can explain decision-making in humans under conditions of need in a foraging analogue (Chapter Five), and circumstances of inequality (Chapter Six). The results of the experiment presented in Chapter Five suggest that humans make decisions under risk that conform to the predictions of risk-sensitivity theory. Chapter Six comprises four experiments examining whether situations of need, manifesting through systemic inequality or competitive disadvantage, predict risk-taking behavior. The results of these experiments suggest that need is an important motivator of risky behavior, and that eliminating situations of need lead to subsequent reductions in risky behavior.

A summary of the findings of the studies reported in this dissertation and some important implications of this work are provided in Chapter Seven. Briefly, the research presented in this dissertation suggests that risk-taking is a general phenomenon that is heavily motivated by considerations of need. These results have important implications for devising social policy that leads to reductions in various forms of societally harmful risky behavior: Aiming to affect modifiable causes of risk-taking, such as inequality manifesting through unequal access to health care, education, and other opportunities, may lead to significantly lower engagement in risky behavior.

CHAPTER TWO

Towards an Integrated Theory of Decision-Making Under Risk: Perspectives from Economics, Biology, and Psychology

Abstract

The study of decision-making under risk is of notable importance to all of the behavioral sciences, including economics, biology, and psychology: Virtually every decision is made under some consideration of risk. Even given this ubiquity, decision-making under risk has been variably characterized and investigated in different disciplines. This review critically examines the most influential frameworks for decision-making under risk developed in economics (expected utility theory), biology (risk-sensitivity theory), and psychology (prospect theory and heuristic approaches). These various theoretical frameworks are integrated into a single theory that offers both ultimate and proximate explanations for risky decision-making. Robust, well-validated empirical findings regarding decision-making under risk are reviewed and used as a basis for the integration of disparate theories of decision-making across disciplines. This comprehensive theory of decision-making is conceptualized around the central hypothesis that decision-makers seek to maximize proxies of fitness.

Introduction

The study of decision-making under risk is of notable importance to all of the behavioral sciences, for good reason: Almost every human and non-human animal decision is made under some consideration of risk. Trading commodities on the stock market involves risk, as does foraging, asking someone out on a date, or aggression towards a competitor (Holton, 2004). In everyday vernacular, risk usually refers to a chance of a negative outcome occurring. Other terms that have been used more or less synonymously with risk include uncertainty, exposure to danger, or hazard, among other more discipline-specific terms (e.g., Knight, 1921; Winterhalder, Lu, & Tucker, 1999). Although risk has been widely studied in various disciplines, in a wide array of species, and in various social and environmental contexts, there has been little progress towards a common framework for examining risky decision-making in the various behavioral sciences.

Some researchers in economics, biology, and psychology have converged on a definition of risk as outcome variance, where the riskier of two options with the same expected value is that with higher outcome variance (e.g., Bernoulli, 1738; Daly & Wilson, 2001; Friedman & Savage, 1948; Real & Caraco, 1986; Rubin & Paul, 1979; Winterhalder et al., 1999). For example, a 50% chance of receiving $10 is a riskier option than receiving $5 with certainty. Other conceptions of risk include unpredictability, uncertainty, and exposure to danger. Although they appear to be different, these different conceptions of risk all involve outcome variance. Thus, explaining decision-making under risk requires explaining why decision-makers sometimes prefer high variance options over low variance options and vice-versa.

Several theoretical frameworks for examining decision-making under risk have been developed in disparate fields. In economics, "rational" models of risky behavior such as expected utility theory have dominated. Psychological conceptions of risky decision-making have been broader, including risk-taking as a product of cognitive processes (e.g., prospect theory, heuristic approaches; Brandstätter, Gigerenzer, & Hertwig, 2006; Kahneman & Tversky, 1979; Todd & Gigerenzer, 2000), and more recently, a product of evolutionarily adaptive mechanisms (e.g., young male syndrome; Wilson & Daly, 1985). Biologists have developed risk-sensitivity theories based on maximization of reproductive success or fitness (Kacelnik & Bateson, 1996, 1997; Stephen & Krebs, 1986).

These various theories take very different approaches to explaining decision-making. Normative (or functional) theories of decision-making involve a top-down approach concerned with identifying the most "rational" decision in a given situation, where rationality is defined by decisions that maximize a currency of interest. Normative theories attempt to describe what organisms ought to do in a given decision-making situation, and have been derived from expectations regarding currencies of maximization. Most theories of decision-making under risk in economics and psychology explain decisions in terms of the currency of utility, where utility broadly defined is a measure of happiness, gratification, or satisfaction derived from a behavior (in economics, usually the consumption of a good or a service). Theories of decision-making in biology, however, have focused on the maximization of the universal biological currency of fitness, where fitness refers to the reproductive success of individuals (and the genes contained within them) over time.

Descriptive (or mechanistic) theories involve a bottom-up approach concerned with identifying proximate mechanisms involved in decision-making. Descriptive theories have mostly been constructed from apparent violations of the predictions of normative theories, and describe how organisms make decisions, rather than why they make decisions. Although descriptive theories are often contrasted with normative theories of decision-making, they too involve a currency of maximization. It is difficult to conceive of a predictive theory of decision-making without specifying goals or aspirations that motivate decision-making, and specifying such goals or aspirations requires defining a currency of maximization, even if it is an abstraction.

Any broad, general theory of decision-making must therefore contain two components. The first component is a normative rationale for decision-making involving a clear definition of a currency of maximization. The second component is some conception of the mechanisms underlying decision-making. For an integrated, comprehensive theory of decision-making, it is not enough to argue that decision-makers seek to maximize a currency of interest; some elucidation of perceptual and cognitive mechanisms is necessary to address how decision-makers perceive and compare decision options, and make choices.

In this chapter, I seek to (1) critically review the most influential frameworks that have been used to study decision-making under risk in the behavioral sciences, specifically, expected utility theory (economics), prospect theory and heuristic approaches (psychology), and risk-sensitivity theory (biology), (2) review empirical data that any general theory of decision-making must explain, and (3) integrate various theoretical perspectives and empirical findings into a general theory of decision-making under risk.

Theories of Decision-Making under Risk

Expected Utility Theory

Expected utility theory stems from Bernoulli's (1738) proposed solution to the St. Petersburg paradox. Consider a game in which an individual must decide the maximum amount of money they are willing to pay as an entry fee. The game is played by flipping a fair coin until it comes up heads, and the total number of flips (n) determines the amount of the prize, $\$2^n$. If the coin shows a heads on the first flip, the coin can be flipped again, until a tails shows up. The player then earns $\$2^n$, where n is the number of heads that show up in a row. The expected value of the gamble is infinite, and thus, any "rational" player should wager any finite amount for the opportunity to play (Bernoulli, 1738):

$$(1/2) \times \$2 + (1/4) \times \$4 + (1/8) \times \$8 + (1/16) \times \$16 + ... + (1/n) \times \$2^n = \infty$$

Most people, however, would not even wager $25 to play the game, and the probability of winning more than $4 is less than 25 percent (Hacking, 1980).

Bernoulli (1738) proposed a solution the St. Petersburg paradox, and in doing so, provided the first conception of expected utility theory. Bernoulli proposed that money has decreasing marginal utility: A dollar is not worth much to a wealthy person, but to a poor person, a dollar is extremely valuable. Similarly, the utility of five million dollars is not five times that of one million dollars. Thus, in addition to the absolute value of a decision outcome (e.g., dollars earned), people may identify some additional subjective value, or utility, to any decision outcome. Expected utility is computed as the utility of any decision outcome multiplied by its probability. Expected utility theory predicts that decision-makers seek to maximize utility in all decisions, where utility is broadly defined as a measure of happiness, gratification, or satisfaction derived from a behavior (Friedman & Savage, 1952).

Early conceptions of expected utility theory posited three types of utility functions describing the relationship between the expected value of a decision and perceived utility. These three curves summarize risk-indifference, risk-aversion, and risk-preference (von Neumann & Morgenstern, 1944). Each of the three types of utility curves differs in its quantification of marginal utility, defined as the change in utility that occurs for every unit change in reward. The risk-indifference curve describes a linear relationship between marginal utility and wealth (or some other currency associated with happiness or gratification) (Figure 2.1A). The risk-averse, concave-down function exemplifies the law of diminishing returns that is widely held to characterize decision-making, where each additional unit of reward is less valued than the last. According to this law, for example, receiving $10 when one starts at $0 confers substantially more utility than if one starts at $10,000 (Figure 2.1B). The risk-preferring, concave-up curve provides an example of a utility curve that describes a situation where each individual unit of reward is valued more than the last (Figure 2.1C).

It was originally suggested that these curves describe consistent patterns of behavior among individuals (von Neumann & Morgenstern, 1944). For example, a risk-averse individual's decision-making would be consistently characterized by a concave-down function. Changes in the environment of decision-making were implicated in possibly influencing the steepness of the curve, but the general shape was argued to remain stable for individuals (von Neumann & Morgenstern, 1944). This conception of stability in risk, however, is problematic. Decision-making behavior is characterized by what appears on the surface to be inconsistency: The same individuals often purchase lottery tickets (exhibiting risk-proneness), as well as insurance (exhibiting risk-aversion), for example.

Another problem with expected utility theory is its conception of utility. Utility as a currency of maximization is difficult to operationalize because utility can take many forms. For humans, these forms may include wealth, happiness, opportunity, or any other positive reward in various domains of life. Thus, any decision is easy to justify *post-hoc* by claiming that the decision-maker maximized utility simply by focusing on a different axis of utility. For a normative theory, expected utility theory offers little predictive value.

Prospect Theory

A compelling criticism of expected utility theory is its inability to predict decisions under various conditions (e.g., Allais, 1953, Ellsburg, 1961, Kahneman & Tversky, 1979; reviewed in Aktipis & Kurzban, 2004; Barrett & Fiddick, 1999; Rode & Wang, 2000), the most well-known of which is the framing effect (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981). Kahneman and Tversky demonstrated that people shift risk-preference between options with equal expected outcomes in identical problems that are differentially framed in terms of losses or gains. Specifically, people tend to be risk-prone when faced with a decision framed as a loss and risk-averse when faced with a decision framed as a gain. Consider the classic Asian disease problem (Tversky & Kahneman, 1981, p. 453):

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

In the standard version of the Asian disease problem, participants are provided with a decision scenario involving a choice between two options, either presented in a positive or a negative frame. The positive frame states:

(1) If Program A is adopted, 200 people will be saved.

(2) If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.

In this positive frame, both options are phrased in terms of the possibility of saving people, and thus, in terms of gains. When presented with this positively framed scenario, Tversky and Kahneman (1981) found that 72 percent of participants preferred the certain option (Program A) over the risky option with higher outcome variance (Program B). The negative frame states:

(1) If Program C is adopted, 400 people will die.

(2) If Program D is adopted, there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will die.

Here, both options are negatively framed in terms of the number of possible deaths, and thus, in terms of losses. Tversky and Kahneman found that when presented with this loss scenario, participants' risk-preferences reversed: only 22 percent of participants preferred the certain option (Program C). This finding of risk reversal in mathematically identical decisions made in loss and gain frames has received substantial empirical support (reviewed in Levin, Schneider, & Gaeth, 1998; for a meta-analysis, see Kuhberger, 1998).

Kahneman and Tversky (1979) conceived prospect theory to explain the systemic violations of expected utility theory they observed in conducting empirical studies with human subjects. Specifically, prospect theory addresses the framing effect (or reflection effect), described above, in addition to the certainty effect and the isolation effect. The certainty effect describes the tendency for people to overweight outcomes that are certain (e.g., sure gains or sure losses) over those that involve probability, regardless of expected value. The isolation effect describes the finding that people ignore common components of decision alternatives in order to simplify decisions (Kahneman & Tversky, 1979).

Kahneman and Tversky (1979) proposed that two phases—the editing and evaluation phases—describe the mechanisms underlying decisions under risk. The editing phase serves to reformulate and organize all of the possible decision options to simplify evaluation (Kahneman & Tversky, 1979), and involves the following operations.

Coding. People code gains and losses around a reference point, where outcomes below the reference point represent losses, and outcomes above the reference point represent gains. References points are derived from an individual's present state, but can change based on expectations or biases of decision-makers (Tversky & Kahneman, 1981).

Combination. Decisions involving identical outcomes and probabilities can be simplified by summed combination. For example, two choices presented sequentially, each involving a 25 percent chance of receiving $200, would be combined into a single choice involving a 50 percent chance of receiving $200.

Segregation. Decisions with riskless components are separated from risky components. For example, a choice between an 80% chance of receiving $300 and a 20% chance of receiving $200 is perceived as a sure gain of $200, with an 80% chance of receiving an extra $100 (Kahneman & Tversky, 1979)

Cancellation. In multi-step decisions, similar elements are ignored (e.g., common outcome/probability pairs). If someone is faced with several choices, all of which have a common element (e.g., two choices each containing a 20% chance to receive $100), the decision is made between remaining probability pairs with the common pair canceled out.

The second phase of a decision is the evaluation phase, where an individual assesses all of the edited options and makes a decision. The evaluation phase consists of a value function and a weighting function. The value function assigns specific values to certain outcomes. Here, the law of diminishing returns applies; the difference between $1 and $2, for example, is perceived as greater than the difference between $500 and $501. Because of the law of diminishing returns and the differential values placed on gains and losses, the utility curve for prospect theory preferences (analogous to a utility function) is concave-down above a reference point (i.e., exhibiting risk-aversion for gains), and concave-up below a reference point (i.e., exhibiting risk-proneness for losses). The reference point refers to the origin of the utility function, around which gains and losses are defined (Figure 2.2).

The weighting function describes overweighting of small probability events and underweighting of medium and high probability events (i.e., emphasizing the salience of certain and/or rare events, Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). In prospect theory, the value of each outcome is multiplied by the decision weight of that particular outcome, leading to some quantification of the utility of decision options. This operation is similar to that involved in computing utility in expected utility theory. Here, participants engage in processing of decisions involving both the editing and evaluation phase prior to making a final decision, leading a subjective evaluation of utility.

Prospect theory can be largely considered an amendment to expected utility theory. Utility remains the currency of maximization, and its definition is unchanged from that in expected utility. Although prospect theory describes mechanisms of decision-making that take into account some systemic empirical violations of expected utility theory preferences, it still suffers from the shortcomings of a poorly defined currency of maximization.

Risk-Sensitivity Theory

Risk-sensitivity theories were developed by behavioral ecologists to explain food acquisition decisions in animals. Instead of focusing on the goal of maximizing utility, risk-sensitivity theories were originally conceived to explain risky decisions in the context of foraging. Specifically, decision-making was characterized as responses of organisms designed to maximize foraging returns in stochastic environments, with the ultimate goal of maximizing biological reproductive success or fitness (Weber, Shafir, & Blais, 2004).

Caraco, Martindale, and Whittam (1980) provided the first conception of risk-sensitive decision-making based on research examining yellow-eyed junco birds. Birds had to choose between two potential food patches, each with the same expected value, but one risky (high variance), and the other certain (low variance). Caraco et al. constructed utility curves (similar to those used in expected utility theory) for individual juncos based on their risk preferences, but did so under two different energy budgets: Positive energy budgets, where juncos were provided with enough food to meet their daily energy requirements, and negative energy budgets, where an inadequate amount of food to meet daily requirements was provided. Caraco et al. found that juncos in negative energy budgets were substantially more risk-prone compared to those in positive energy budgets. This finding is specifically known as the energy-budget rule (Stephens, 1981; Stephens & Krebs, 1986).

Consider a foraging bird that must consume 1,000 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 had already acquired 900 calories through the day and requires 100 more to meet its caloric need for the night (a positive energy budget), its survival is guaranteed if it forages from the low-risk patch. If the bird has acquired 800 calories through the day and requires 200 more to survive (a negative energy budget), 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. Most organisms are generally risk-averse for amount of reward (Kacelnik & Bateson, 1996, 1997; Daly & Wilson, 2001). Risk-aversion switches to risk-preference, however, when a *need* (like a negative energy budget) must be fulfilled that cannot be satisfied with a low-risk option.

Risk-sensitivity theory predicts that decision-makers shift from risk-aversion to risk-preference in situations of need, where need refers to a disparity between an individual's present state and desired state (Mishra & Lalumière, 2010a). Someone with a $500 debt, for example, may prefer a 10% chance of winning $500 over earning $50 with certainty. Although both options have the same mean payoff, the riskier option at least allows for a chance to meet one's need. Therefore, according to risk-sensitivity theory, decision-makers do not seek to necessarily maximize desirable outcomes, but rather, seek to avoid outcomes failing to meet their needs (Stephens, 1981; Stephens & Krebs, 1986). Put another way, decision-makers seek to avoid outcomes that ultimately harm reproductive success or fitness.

Heuristic Approaches

Heuristics are "rules of thumb" devised to allow for quick and efficient decision-making. They are usually the products of inductive reasoning from actual patterns of decision behavior, and as such, represent a descriptive approach to explaining decision-making. Decision-making heuristics can be broadly divided into two categories. Outcome heuristics only involve the use of outcome information, and ignore probabilities when making a decision. For example, the minimax heuristic involves selecting an outcome with the highest minimum payoff (Thorngate, 1980). Dual heuristics use both outcome information and probability information; the lexicographic heuristic, for example, involves determining the most likely outcome and the payoff of each decision, and then selecting the outcome with the highest and most likely payoff (Thorngate, 1980). Numerous heuristics have been developed in an attempt to explain decision-making behavior (reviewed in Brandstätter et al., 2006).

Traditional theories of decision-making, including most heuristic models, suffer from an important limitation in that it is assumed that decision-makers have an unlimited capacity for processing information related to decision options. However, most real-world decisions are made quickly, with incomplete information about all possible outcomes. Therefore, any compelling theory of decision-making must acknowledge limitations of cognitive processing (e.g., Todd & Gigerenzer, 2000).

Several amendments to traditional utility theories have been proposed to try and model more realistic decision-making behavior. Optimization under constraint approaches describe decision-makers as calculating stopping rules that dictate when to cease searching for reasonable decision options. Specifically, it was suggested that decision-makers calculate the best possible decision by weighing the costs and benefits of searching for further information regarding alternative decision outcomes, and stop searching for alternatives as soon as costs exceed benefits (Todd & Gigerenzer, 2000).

The most significant problem with utility theories and models of optimization under constraint is the notion of optimization itself. In most real-world situations, it is impossible to arrive at an optimal outcome given the sheer number of decision options available and the amount of uncertainty inherent in the environment (i.e., the degree to which decision outcomes are unknown). An alternative approach to optimization—known as satisficing—describes decision-making as not necessarily characterized by seeking optimal outcomes (i.e., maximizing), but rather, seeking outcomes that meet one's needs (Simon, 1956). In this sense, satisficing is similar to decision-making mechanisms posited in risk-sensitivity theory, in that decision-makers are only required to set an aspiration level, or need, and then seek options that are able to meet this aspiration, or need.

Satisficing represented an early conceptualization of bounded rationality, which acknowledges the inherent limitations involved in information search and decision-making (Simon, 1956). Bounded rationality is contrasted with traditional models of unbounded rationality (e.g., expected utility theory, prospect theory), which dictate that decision-making processes need not have any limitations on the ability to compute optimal decisions. Of course, satisficing still involves decision-making rules that are not necessarily the most efficient. Recently, fast and frugal heuristics have received substantial attention as effective candidates for explaining decision-making behavior.

Fast and frugal heuristics are defined by their efficiency regarding time, knowledge, and computational requirements for decision-making. An example of a fast and frugal heuristic is one-reason decision-making, where a single piece of information is used to make a decision (e.g., in searching for a mate, stopping a search once a mate taller than 6 feet is found; Todd & Gigerenzer, 2000). Using a single piece of information to make a decision avoids the pitfalls of having to combine different currencies (e.g., height and income potential).

Fast and frugal heuristics are also necessarily constrained by environments of decision-making. In order to construct simple decision-rules, it is necessary to take into consideration how information is structured in the environment (e.g., foraging patches tend to consist of clumped resources at distance from each other; Wilke, Hutchinson, Todd, &

Czienskowski, 2009). In this sense, fast and frugal decision-making reflects what is known as ecological rationality. If decision-making is ecologically rational, it must also necessarily be robust, allowing decision-rules to be broadly used in different environments.

The priority heuristic is a fast and frugal heuristic that has received recent empirical attention. The priority heuristic involves three rules, utilized in order until a clear preference is established (Brandstätter et al., 2006). The priority rule dictates that from most to least important, the parameters for a decision are minimum gain (or loss), probability of minimum gain (or loss), and maximum gain (or loss). The stopping rule dictates that choice alternatives will cease to be examined if the minimum gains are 1/10 (or more) different from the maximum gains. Otherwise, choice examination will cease if probabilities differ by 1/10 (or more. Finally, the decision rule dictates that the option with the most attractive probability of gain will be chosen. Interestingly, the priority heuristic does not require any conception of aspiration (or need) level. The priority heuristic has been shown to be among the most effective heuristics in predicting risky choice in various decision scenarios, although its frugality varies considerably based on the complexity of decision problems (Brandstätter et al., 2006).

Heuristics offer simple descriptions of mechanisms through which decision-making takes place. They describe the manner in which decision-makers perceive their environment, collect information regarding a decision, and choose between decision options. Although many heuristics for decision-making have been developed, most do not adequately acknowledge the computational speed and efficiency with which most decisions are made. Of course, more deliberative decisions involving careful consideration of decision options and potential outcomes may work through less efficient and more optimization-focused means.

However, an ecologically rational conception of decision-making that seeks to explain most decision-making behavior must account for the speed and efficiency of decision-making, as well as the structure of information in the environment.

Towards a General Theory of Decision-Making Under Risk

Both normative and descriptive theories are important to the study of decision-making. Descriptive theories primarily give rise to proximate explanations of the causes of decision-making, and often stem from systematic violations of normative theories. A solely descriptive approach, however, lacks the primary virtue of normative approaches: The ability to offer functional explanations of *why* particular patterns of decision-making occur. This section describes a model of decision-making under risk derived from integrating the most widely supported empirical findings regarding decision-making under risk, in addition to integrating components of descriptive theories (e.g., the findings of prospect theory), with some of the most important predictions from normative theories (e.g., the maximization of utility in decisions). In this section, I (1) suggest a general currency relevant to decision-making in disparate domains, and (2) examine the proximate causes for risk-sensitive decision-making.

Normative or functional theories of decision-making under risk seek to explain why particular decisions are made. However, of established normative theories, only risk-sensitivity theory explicitly acknowledges the pursuit of reproductive success or fitness as an overarching goal for decision-making behavior. Other normative theories actually focus on proximal goals—the short-term maximization of utility for example, where utility usually describes monetary gains—rather than functional goals. Because both non-human and human decision-makers are the products of evolution by natural selection, it is necessary for any theory of decision-making under risk to explicitly acknowledge the underlying fitness-relevant motivations driving most behavior.

Of the influential theories of decision-making under risk reviewed here, only risk-sensitivity theory has received broad and robust empirical support from both human and animal studies (reviewed in Kacelnik & Bateson, 1996, 1997; Mishra & Lalumière, 2010a). Both human and non-human animals appear to consistently make decisions conforming to the predictions of risk-sensitivity theory: Organisms tend to prefer high-risk options under conditions of high need, and low-risk options under conditions of low need (Deditius-Island, Szalda-Petree, Kucera, & 2007; Mishra & Fiddick, 2010; Mishra, Gregson, & Lalumière, 2010; Mishra & Lalumière, 2010a; Pietras & Hackenberg, 2001; Pietras, Locey, & Hackenberg, 2003; Rode et al., 1999; Wang, 2002). Beyond this small literature, however, risk-sensitivity theory has been surprisingly ignored in the broader human judgment and decision-making literature. Because risk-sensitivity theory is the only theory of decision-making that explicitly acknowledges the relevance of fitness, however, it requires further attention.

The Currency of Decision-Making

A difficulty in reconciling the various frameworks of risk is deriving an operationalizable currency. It is difficult to understand the perceived or actual costs and benefits of any given decision without describing a single common currency (Daly & Wilson, 2001). Economic and psychological accounts of risky decision-making tend to focus on the maximization of utility, broadly defined. Biological models such as risk-sensitivity theory are primarily concerned with the acquisition of energetic resources, and ultimately, the maximization of reproductive success or fitness.

The currency of utility suffers from the problem of being vague and ill-defined. It is too easy to argue that utility is always being maximized in decisions *post hoc*, because utility can take many forms: Happiness, monetary outcomes, or a feeling of well-being all represent possible forms of utility. The currency of fitness suffers from a similar problem of being difficult to quantify and operationalize in the context of everyday decisions. However, both human and non-human animals seem to make decisions as if they were aware of the costs and benefits of a particular course of action with regards to fitness consequences (e.g., foraging birds make decisions that seemingly balance the risk of death against caloric rewards; Daly & Wilson, 2001). Regardless, it is difficult to quantify and operationalize fitness in the context of everyday decisions, especially given that fitness strictly refers to the average contribution of a particular individual's genotype to the gene pool of the next generation. Therefore, it is necessary to focus on more concrete proximate outcomes—those that have been statistically associated with fitness over evolutionary history—as currency that decision-makers seek to maximize.

From an evolutionary perspective, resources associated with reproductive success or fitness are of utmost importance; these include material resources, social status, and mating opportunities (Daly & Wilson, 2001). Throughout evolutionary history, people who had plenty of resources, high status, and quality mating opportunities were more likely to reproduce and create high-quality offspring that were likely to survive compared to those who possessed few resources, low status, or no mating opportunities. People sensitive to these correlates, or proxies, of fitness likely left more descendants than those who were not. Thus, over time, acquiring resources, status, and mating opportunities have become, through evolution by natural selection, needs that animals, including humans, aspire to meet. Because such proxies of fitness are necessarily associated with actual fitness, such proxies would have been selected for as motivations guiding decision-making behavior.

The Motivational Effect of Need on Decision-Making

Conditions of need describe disparity between a present state and a goal or desired state (Mishra & Lalumière, 2010a). If the disparity between a goal state and a present state increases, organisms should make decisions that seek to bridge that disparity through any means necessary. Thus, risk-acceptance should increase in situations of high need. How do organisms weigh needs in different domains? Life history theory seeks to explain how organisms allocate limited time and energetic resources to various biologically important functions, such as survival, growth, reproduction, and parental investment. A key concept in life history theory is tradeoff: Organisms must allocate a finite amount of effort or energy to endeavors that constrain each other, such as number and size of offspring (Stearns, 1992). Natural selection favors the allocation of effort or energy contingent on the features of a particular environment (Kaplan & Gangestad, 2005).

One example of a well-documented life history tradeoff occurs between long-term survival and current reproduction. The twin-threshold model of risk-sensitivity theory incorporates predictions about both survival and reproduction (Hurly, 2003). This model suggests that decision-makers are sensitive to both survival needs and reproductive needs. Risk-proneness may thus be observed when an individual is close to a reproductive threshold; taking a risk in order to ensure reproduction may be more beneficial than engaging in risk-averse behavior and potentially losing the opportunity to reproduce at all, even if taking a risk compromises survival (Bednekoff, 1996; Hurly, 2003). A comprehensive review of how life history tradeoffs affect risk-acceptance is beyond the scope of this chapter, but has been reviewed elsewhere (Mishra & Lalumière, 2008).

From an evolutionary standpoint, survival is meaningless without reproduction. However, it is obviously impossible to reproduce without surviving. Thus, decision-making regarding basic survival needs must function to maintain homeostasis. Because survival is paramount, decisions regarding basic survival needs should always be prioritized in circumstances where the possibility of reproductive success is significantly compromised. Any perception of need in a survival domain should thus be particularly salient.

Perception of need can also stem from the comparison of one's present social condition with the social condition of others in a population. Fitness is relative: In order to have one's genes disproportionately expressed in the next generation, it is necessary to outcompete others. As a consequence, motivations underlying decision-making should also be relative. Needs in evolutionarily salient domains—obtaining material resources, gaining status, and obtaining mating opportunities—should be defined relative to the accomplishments of others. Some evidence suggests that people are particularly sensitive to relative disparity. For example, most people would prefer a smaller 2000 square foot house in a neighborhood full of 1,000 square foot houses than a twice-as-large 4000 square foot house in a neighborhood full of 6,000 square foot houses (Frank, 2000). Relative outcomes should thus be privileged in decision-making, and the perception of need— disparity between one's present and desired state, where one's desired state is dictated by the state of others—captures this sensitivity to relative standing effectively.

If the perception of need drives decision-making, how do decision-makers choose options that maximize the probability of meeting their needs? Although originally conceived to explain foraging patterns in non-human animals, risk-sensitivity theory can be generalized to almost all decision-making contexts. If someone is far from an acceptable threshold (e.g., possessing low income, or poor social status), it is possible that they would behave as animal foragers do, and engage in risk-accepting behavior (Caraco, 1983; Caraco et al., 1980; Caraco & Lima, 1985). Of course, this decision-making can occur in various different domains. Someone in a situation of high economic or financial need, for example, may be more likely to engage in high-risk behaviors in that specific domain (Daly & Wilson, 2001). In support of this notion, people in conditions of high economic need (also known as relative deprivation) appear to be more likely to engage in pathological gambling, a risky behavior that exposes one's resources to high variance outcomes (e.g., Callan, Ellard, Shead, & Hodgins, 2008). The degree to which need-based decision-making is domain-specific, however, is still an open question.

To summarize, the historical pursuit of reproductive success or fitness has shaped motivations underlying decision-making. Decision-makers seek to obtain material resources, status, and mating opportunities that have been significantly correlated with fitness over evolutionary history. Acquiring these correlates of fitness have become needs that organisms aspire to meet. Risk-sensitivity theory suggests that decision-makers should elevate risk-acceptance in situations of high need, when low risk options are unlikely to meet one's needs. Because success in competition is relative, decision-makers' levels of perceived need are dictated by their relative position compared to others. Someone with low status, for example, may engage in risk-taking if they are unable to elevate their status using low-risk means. Although this approach is informed by evolutionary theory, it has the added virtue of explicating a simple mechanism underlying choice in almost any domain. Even in non-evolutionarily salient domains (e.g., making a purchase decision for a non-essential item), decision-making can be effectively described by risk-sensitivity theory: If a purchaser feels a need for a particular item, for example, they will seek options that allow them to meet their perceived need for that particular item.

Elucidating Mechanisms Underlying Decision-Making

To develop a general theory of decision-making, it is necessary to account for various empirical findings that have been widely replicated and validated. In this sense, any framework for understanding risk must necessarily be in part descriptive. In this section, I review well-validated empirical findings regarding decision-making under risk that any comprehensive theory of decision-making must account for, and discuss proximate mechanisms of causation and development that may give rise to risky behavior. Here, decision-making is conceived generally to describe any decisions involving the potential for variability in outcome.

Perceptual and Cognitive Biases

Substantial evidence suggests that framing effects in humans are highly replicable, with people reliably exhibiting elevated risk-acceptance in situations of loss, and risk-aversion in situations of gain (reviewed in Kuhburger, 1998; Levin et al., 1998). Framing effects have not, however, been widely supported in the animal literature. Marsh and Kacelnik (2001) demonstrated that starlings elevated risk-acceptance in loss situations in a framing effect analogue, but did not exhibit risk-aversion in gain situations. Others have demonstrated similar effects in humans, suggesting that framing effects may be largely driven by loss-aversion (Mishra & Fiddick, 2010; Mishra, Gregson, & Lalumière, 2010).

The weighting function in prospect theory addresses the observation that people do not make decisions that directly coincide with the probabilities of different outcomes.

Rather, people tend to overestimate the salience of both certain and rare events (Hertwig, Barron, Weber, & Erev, 2004). It is possible that these biases reflect the salience of such information; high probability events should be treated as salient because near-certainty is particularly valuable in stochastic environments. Rare events may also be disproportionately influential in decision-making because of the potential of experiencing a very large gain, or a very large cost. For example, people consistently overestimate the probability of winning the lottery, and the probability of such catastrophic events as terrorist attacks (Armantier, 2006).

People exhibit anchoring or focusing effects in decision-making, emphasizing particular dimensions of a decision and discounting others. For example, in making a decision to purchase a car, some consumers may overemphasize the importance of an odometer reading and discount the overall condition of the car. Similarly, people tend to focus on the negative aspects of a decision over positive aspects. Negative outcomes are more salient in decision-making than positive outcomes. Thus, both the anchoring/focusing effect and negativity bias may represent manifestations of cost-avoidance.

Mood

Studies have demonstrated that negative moods such as anger, frustration, and sadness have been associated with increased risk-taking (e.g., Fessler, Pillsworth, & Flamson, 2004; Leith & Baumeister, 1996; Mishra, Morgan, Lalumière, & Williams, 2010). Conversely, positive mood states have been associated with risk-aversion (e.g., De Vries, Holland, and Witteman, 2008; Isen & Patrick, 1983; but see Hills, Hill, Mamone, & Dickerson, 2002). Isen and Patrick introduced the mood-maintenance hypothesis to explain these findings. Specifically, they suggested that people in positive moods avoid risk to maximize the likelihood of maintaining their positive mood, and people in negative moods seek risk in an attempt to obtain gains that might ameliorate their negative mood (Arkes, Herren, & Isen 1988; Isen, Nygren, & Ashby, 1988).

Negative moods may be an important proximate mechanism that drives the relationship between need and risky decision-making. Because need represents disparity between a present and a desired state, it is a form of perceptual inequality. Inequality has been associated with negative mood states (e.g., Lorant, Deliege, Eaton, Robert, Philippot, & Ansseau, 2003). As a consequence, it is possible that negative moods may motivate decision-making that allows for the possibility of obtaining gains that might meet one's needs, and thus ameliorate negative moods.

More recent theoretical approaches have conceptualized "risk as feelings". Loewenstein, Weber, Hsee, and Welch (2001) suggested that traditional models of decision-making under risk—what they call the consequentialist perspective—ignore the predictive role of emotions. They alternatively hypothesized that emotions sometimes affect cognitive evaluation of choice options, such that the perception of decision options changes based on mood state.

Individuals in different situations of need may perceive the relative costs and benefits of decision options in different ways. For example, people engage in significantly higher risk-accepting behavior when induced to experience negative moods (Leith & Baumeister, 1996). The costs and benefits of risky behavior may be perceived differently as a function of need condition. People in conditions of high need may de-emphasize the high probability of losses and emphasize the small possibility of large gains involved in a high-risk decision. This change in perceived cost-benefit may in turn change the affective properties of a particular decision option. People in conditions of high need may "feel" better about risky decisions, and consider them more attractive as a result. Some risky decisions, such as choosing to engage in property or violent crime may not necessarily "feel" like a pleasant option, but rather, they may feel exciting, or at least "less worse" than other less risky options. As such, decision-making based on affect may facilitate making the best of particular circumstances.

Age and Sex Differences

Males are significantly more risk-accepting than females in both humans and non-human animals. In a meta-analysis, Byrnes, Miller, and Schafer (1999) demonstrated that men engaged in significantly more risk-taking in 14 of 16 domains studied. Age also plays an important role in the engagement of risky behavior. The classic age-crime curve shows that individuals age 16 to 24 are substantially more likely to engage in criminal and risky behavior, especially men (Wilson & Daly, 1985). Furthermore, risky behavior is largely normative in adolescence and early adulthood in males, and in a large proportion of females (Moffitt, 1993).

Wilson and Daly (1985) suggested that young males age 16 to 24 are particularly likely to engage in risk-accepting behavior because competition for status, mates, and resources during that period reaches its peak—a phenomenon they termed the "young male syndrome". Furthermore, young males not only compete with each other, but also compete with older males who have had more time to accumulate skills, resources, and status, all features important to obtaining mating opportunities.

If young males are at competitive disadvantage relative to other males (because of youth and relative inexperience), and are in situations of intrapersonal competition, they are experiencing high need. Thus, risk-taking may be engaged in to try and meet one's social needs in particularly competitive circumstances. The same mechanism can explain desistance from risky behavior: Marriage and stable work are reliable correlates of desistance from risky behavior (reviewed in Mishra & Lalumière, 2008). That risk-taking tends to desist in early adulthood reflects changes in the costs and benefits of risky behavior. As risk-takers meet their resource, status, and mating needs, the necessity of risky behavior is reduced. Interestingly, those who lose this stability (e.g., through divorce, or being widowed) subsequently exhibit elevated risk-acceptance, suggesting that risk-propensity is plastic, and heavily contingent on the environment and perceived situations of need (Daly & Wilson, 2001).

Sex differences in risk-taking, both during adolescence and across the life span, can be similarly explained with a consideration of the costs and benefits of risky behavior in the context of life history theory. In most species, males have a substantially higher potential reproductive rate than females. A male can mate with an almost unlimited number of females, whereas females in most species bear the brunt of parental investment costs and are thus limited by physiology and other constraints. Consequently, the sex that must invest more time and energy into reproduction (usually female) becomes a valuable resource for which members of the opposite sex (usually male) compete. Furthermore, because pregnant or lactating females are effectively removed from a pool of potential mates, the operational sex ratio is often heavily skewed toward males, facilitating increased male-male competition for the limited number of available females.

Risk-sensitivity theory can explain both age and sex differences in risky behavior. Young males in highly competitive environments tend to escalate risky behaviors in various domains. Because of this highly competitive environment, males often experience relative disparity between their present and desired states (where their desired state is derived from the relative successes of competitors in the domains of resource holding potential, social status, and mating opportunities). Furthermore, young males are disproportionately sensitive to status disparities, and risk-taking often represents a "badge of honor" (Wilson & Daly, 1985; Daly & Wilson, 2001). Consequently, young males are usually in a situation of higher need compared to females, and engage in elevated risk-taking behavior as a consequence. With changing circumstances, the costs and benefits of risky behavior shift, motivating different patterns of risk-acceptance.

Individual Differences

Traditional models of decision-making under risk do not adequately address individual differences in risk-propensity. Some conceptions of expected utility theory acknowledge that utility curves can vary in their steepness and degree of curvature. Friedman and Savage (1948), for example, suggested that individual utility curves could change concavity based on income, where people should hypothetically be risk-averse at high and low incomes, and risk-seeking at middle incomes. Others have proposed amendments to expected utility attempting to account for why people are sometimes risk-averse and risk-prone (e.g., rank-dependent expected utility theory; Quiggin 1982). Regardless, these theories do not provide a normative rationale for why decision-makers vary highly in their risk propensities across different contexts.

Variability in such personality traits as low self-control, impulsivity, and sensation-seeking have been consistently associated with various forms of risky behavior, including gambling and crime (Blaszczynski, Steel, & McConaghy, 1997; Blaszczynski, Wilson, & McConaghy, 1986; Langewisch & Frisch, 1998; McDaniel & Zuckerman, 2003; Mishra et al., 2010; Skitch & Hodgins, 2004; reviewed in Quinsey, Skilling, Lalumière, & Craig, 2004; Toneatto & Nguyen, 2007; Zuckerman 2007). Furthermore, these individual differences have been demonstrated to exhibit a fair degree of stability over time (Roberts & DelVecchio, 2000), suggesting that personality traits facilitate individual differences in risky behavior (Mishra & Lalumière, 2010b). Animal research further supports this hypothesis, with some evidence suggesting that stable individual differences in risk-taking exist in a variety of species (reviewed in Gosling & John, 1999; Mishra, Logue, Abiola, & Cade, 2010; Sih, Bell, Johnson, & Ziemba, 2004).

How do stable individual differences in risk-acceptance arise? Because environments are heterogeneous, there may be many different adaptive optima for various behaviors in any particular environment (Buss, 2009). For example, variation in selection pressures over time or space may give rise to individual differences in the degree to which a personality trait is expressed. If individual differences in personality traits are relatively stable, then individual differences in such traits may reflect an attempt to establish different behavioral niches in a variable environment (e.g., McDermott, Fowler, & Smirnov, 2008; Wolf, van Doorn, Leimar, & Weissing, 2007). Other stable individual differences seem to be under stronger genetic control, perhaps representing facultative strategies in particular social environments (e.g., psychopathy; Lalumière, Mishra, & Harris, 2008).

Plasticity and the Role of the Environment

Although stable individual differences clearly play a role in facilitating risky behavior, the environment cannot be ignored as a significant factor. Plasticity is always more adaptive than fixed patterns of behavior. The ability to change behavior in response to environmental variation can facilitate an adaptive fit between behavior and environment more consistently. Sensitivity to environmental changes and the ability to change behavior quickly and effectively, however, may be costly, favoring the evolution of more stable individual differences.

Stable individual differences should not be favored or expressed if they impose undue costs. Mishra and Lalumière (2010a), for example, demonstrated that in situations without need constraints (i.e., situations of low need), individual differences in personality—self-control, impulsivity, and sensation-seeking—are predictive of risky choice. In situations with significant need constraints, however, where making a "wrong" decision was particularly costly, individual differences in personality did not significantly account for any of the variance in risky choice. These results suggest that individual differences in personality seem to only manifest when there are low costs in the environment. In situations with the potential for high costs, however, most people, regardless of their personality, behave in a manner predicted by risk-sensitivity theory, exhibiting elevated risky choice in situations of high need (Mishra & Lalumière, 2010a).

In non-human animals, several studies have demonstrated that state-dependent conditions of caloric need (i.e., positive and negative energy budgets) predict risk-taking (reviewed in Kacelnik & Bateson, 1996; 1997). More persistent environmental effects, such as developmental effects, also play a role in motivating risky behavior. Mishra, Logue, Abiola, and Cade (2010) demonstrated that the quality of hissing cockroaches' developmental environment predicted the emergence of individual differences in risk-acceptance as adults. In other animal studies, researchers have shown that risk-preference is affected by ecology and the structure of resources in the environment. For example, it has been demonstrated that chimpanzees are significantly more risk-preferring than closely phylogenetically related bonobos (Heilbronner, Rosati, Stevens, Hare, & Hauser, 2008). It was hypothesized that this divergence was due to differences in foraging: Chimpanzees forage from riskier food sources and thus necessarily exhibit a greater tolerance for risk.

In humans, cues of poor developmental environments, including poor maternal malnutrition, early head injuries, and other forms of neurodevelopmental perturbation have been associated with elevated and persistent risky behavior (reviewed in Anderson, 2007; Harris, Rice, & Lalumière, 2001; Mishra & Lalumière, 2008). These factors typically interact with other social factors related to elevated risk-taking, such as a single-parent upbringing, low socioeconomic status, or parental abuse (Rutter, 1997). Together, neurodevelopmental problems and poor social environments are suggested to decrease intellectual abilities leading to increased impulsivity, decreased sensitivity to punishment, and impaired development of prosocial skills, all of which lead to accelerating preferences for risky behaviors. Other cues associated with the social environment, including low socioeconomic status, divorce, lack of social and familial support, high interpersonal competition and inequality, and the lack of a mate have been associated with various forms of risk-acceptance, including gambling, criminal engagement, promiscuous sexual behavior, school dropout, and substance abuse, among others (reviewed in Mishra & Lalumière, 2008).

More permanent environmental effects, such as neurodevelopmental perturbations and poor nutrition during development, may serve as cues of developmental disadvantage to a mother and her fetus, facilitating the development of psychological mechanisms calibrated to produce risk-accepting strategies (Mishra & Lalumière, 2008). Variation in risk-acceptance may thus be in part due to variation in embodied capital, which refers to intrinsic attributes such as health, or attractiveness that allow for successful competition with others for resources, status, and mates. Individuals who possess low embodied capital may be "fixed" into a situation of high need, where they are consistently at competitive disadvantage relative to others, and must therefore engage in persistent risky behavior in order to compete effectively.

Competitive disadvantage has been empirically shown to influence rates of antisocial and criminal behavior. Wilson and Daly (1997) demonstrated that Chicago neighborhoods with higher local income disparities also experienced higher homicide rates. If one is able to legitimately compete for resources, status, or mates, it is not beneficial to engage in costly risky or criminal behavior. Individuals with low embodied capital, however, may have much to gain and little to lose from engaging in risk-taking behavior. The constraints of low embodied capital may shift the cost-benefit ratio of risky behaviors, making such behaviors more attractive. Because low embodied capital may not be easy to remedy, elevated risk-acceptance may remain optimal throughout the lifespan.

Together, these results indicate that both the social and physical environment play an important role in influencing decision-making under risk. Conditions of need facilitated by early developmental environments and more immediate social environments have been consistently associated with risk-accepting behavior in a pattern that is consistent with the hypothesis that need motivates risk-taking.

The Generality of Risk

Substantial evidence suggests that various forms of risky behavior, including crime, gambling, substance use, dangerous driving, sexual risk-taking, and antisocial behavior co-occur both within individuals and at the aggregate level (e.g., Bartusch, Lynam, Moffitt, & Silva, 1997; Donovan & Jessor, 1985; Hirschi & Gottfredson, 1994, Leblanc & Girard, 1997; Lussier, LeBlanc, & Proulx, 2005; Mishra & Lalumière, 2009; Mishra, Lalumière, Morgan, & Williams, 2010; Mishra, Lalumière, & Williams, 2010; Osgood, Johnston, O'Malley, & Bachman, 1988). Furthermore, individuals who regularly engage in various forms of risk-taking (including gambling and crime) score higher than others on measures of poor self-control, impulsivity, and sensation-seeking (reviewed in Zuckerman, 2007).

Why is engagement in risky behavior a general phenomenon? Both individual differences and sensitivity to the environment can account for general engagement in risk-accepting behavior. Individual differences in personality such as low self-control, impulsivity, or sensation-seeking may lead individuals who possess such traits to seek out risky options by default. As a consequence, such stable individual differences may give rise to domain-general risk-seeking behavior. Individuals developing in disadvantaged environments are significantly more likely to engage in criminal and risky behavior. If poor developmental environments lead to low embodied capital, and low embodied capital facilitates a consistent perception of being at "high need" relative to others, then what appears to be stable patterns of personality (e.g., low self-control, high impulsivity) may actually be byproducts of a common developmental environment.

Stable personality traits may thus represent proximate mechanisms through which a behavioral preference for risky outcomes manifests. It is therefore likely that there is a significant correlation between disadvantaged environments and the development of risk-accepting personality traits. Those who are competitively disadvantaged would experience poorer outcomes in almost every evolutionarily relevant domain. For example, substantial evidence suggests that more attractive, healthier individuals are likely to earn obtain better positions and earn more at their jobs, command higher social status and are more likely to find attractive mating opportunities (e.g., Anderson, John, Keltner, & Kring, 2001; Case & Paxson, 2008). As a consequence, competitive disadvantage should facilitate the perception of need in a domain-general manner, and thus, may explain the generality of risky behavior.

Reconciling Theories of Decision-Making

Risk-sensitivity theory is the only theory of decision-making under risk that explicitly integrates the ultimate pursuit of reproductive success or fitness into its goal structure (manifesting through the pursuit of proxies of fitness). However, there is significant overlap between risk-sensitivity theory and other dominant theories of risk. The definition of utility used in expected utility theory and prospect theory can be re-conceptualized to be more ecologically valid (and thus more compatible with risk-sensitivity theory). Similarly, various mechanisms of decision-making in prospect theory dovetail with mechanisms in risk-sensitivity theory. In this section, I examine the overlap between risk-sensitivity theory and other theories of decision-making under risk.

Expected Utility Theory

Expected utility theory posits that people seek to maximize utility in all decisions, where utility is broadly defined as a measure of happiness, gratification, or satisfaction derived from a behavior (Friedman & Savage, 1952). Expected utility theory suffers primarily from the problem of a vague definition of utility. It is possible to describe any decision as being utility-maximizing *post hoc* by highlighting different axes or dimensions of utility. It is possible to reconcile expected utility theory with need-based decision-making by conceptualizing utility as the likelihood of meeting one's needs. In this sense, meeting one's needs is analogous to maximizing utility.

The utility curves for resource acquisition can be defined similarly to the concave-down function from expected utility theory, which reflects the law of diminishing returns. An ecologically relevant conception of expected utility theory, however, would distill utility from various different domains of behavior into their effect on reproductive success or fitness (Daly & Wilson, 2001; Kenrick et al., 2009). Maximizing utility can thus simply be conceptualized as maximizing outcomes that have been correlated with increased fitness—specifically, the pursuit of social status, material resources, or mating opportunities. This definition is not at odds with the economic definition of utility, but rather re-frames it into a more ecologically and broadly relevant context. Using this conception of utility, the examples provided at the beginning of the paper—trading commodities on the stock market, animal foraging, asking someone out on a date, or aggression between individuals—all involve utility maximization in that they all have some impact on fitness (in these examples, manifesting though resource acquisition, mate choice, and interpersonal competition; Daly & Wilson, 2001).

Prospect Theory

Risk-sensitivity theory also dovetails with prospect theory, providing a normative account for loss-aversion. In fitness terms, marginal losses are much more significant than marginal gains of a similar magnitude; the prospect of not reproducing at all is worse than increasing fitness slightly (Aktipis & Kurzban, 2004; McDermott et al., 2008). A marginal gain in resources may increase the probability of reaching some higher reproductive threshold (Hurly, 2003), or a longer survival time horizon (Aktipis & Kurzban, 2004; McDermott et al., 2008), but even a marginal loss could push an organism closer to death, and therefore closer to a critical threshold of being unable to reproduce (Stephens & Krebs, 1986). As a consequence, it may be adaptive for organisms to be significantly more sensitive to resource losses than to resource gains. This mechanism would explain the function of such cognitive biases as loss-aversion, the focusing effect, and the negativity bias, all of which facilitate sensitivity to outcomes involving loss.

Risk-sensitivity theory predicts that organisms switch from risk-aversion to risk-proneness in situations of high need. This finding is compatible with prospect theory, in that risk-proneness is observed in situations of potential loss, and risk-aversion is observed in situations of potential gain (Kahneman & Tversky, 1979). The utility curve that arises from prospect theory (Figure 2.2) can also be used to describe risk-sensitive foraging behavior under positive energy budgets, or situations of low need (a domain of marginal gains), and negative energy budgets, or situations of high need (a domain of marginal losses).

Risk-sensitivity theory posits that decision-makers seek to maximize certain outcomes, but do so while also seeking to minimize the probability of experiencing outcomes that fail to meet their needs (Stephens, 1981). This prediction mirrors that of prospect theory, where decision-makers engage in risk-taking to maximize gain, but not at the cost of loss (Tversky & Kahneman, 1981). Tversky and Kahneman suggested that reference points (around which gains and losses are defined) are derived from an individual's present state, but can change based on expectations or biases of decision-makers. As a consequence, the reference point in prospect theory may be analogous to a need threshold. Below the reference point, people may perceive themselves to be in a situation of high need, and above the reference point, people may perceive themselves to be in a situation of low need. Thus, the classic finding that people are risk-averse in the face of gains and risk-prone in the face of losses in framed decision scenarios may be a byproduct of people trying to minimize the possibility of experiencing a negative outcome that does not meet their needs. Loss frames confer the perception of high need, supporting this hypothesis (Mishra & Fiddick, 2010; Wang, 2002).

Heuristic Approaches

Most decision-making is quick and efficient. Furthermore, most decisions are made in domains that were recurrently important over evolutionary history. Thus, in order to foster efficiency and speed in decision-making, adaptive decision heuristics must reflect the structure of information in the environment (e.g., foraging patches occur in clumps; mate choice requires some notion of satisficing in order to define a stop point; Todd & Gigerenzer, 2000). In this sense, decision-making should be ecologically rational. Todd and Gigerenzer suggested that ecologically rational decision-making must (1) exploit the structure of information in the environment, increasing the efficiency of decision-making, and (2) be simple enough to be robust in the face of environmental change, allowing for generalization. These two conditions are well met by the mechanisms underlying risk-sensitivity theory.

Many decision-making paradigms used to examine choice behavior in humans are not particularly ecologically valid, in that they reflect decision-making from abstract and often explicit descriptions. Decision-making from description involves providing decision-makers with explicit information about the mean and variance of different choice options. However, most decision-making involves decisions from experience, where decision-makers implicitly learn the yield characteristics of decision options through active interaction (Hertwig, Barron, Weber, & Erev, 2004). Recent research indicates that people can effectively make risk-sensitive decisions under need involving decision-making from experience (Mishra & Lalumière, 2010a). This process better reflects how knowledge would be acquired in most environments. Thus, decision-making under need conforms to the first requirement of ecological rationality, whereby decision-makers consider different options by exploiting the natural structure of information in the environment.

Domain-specific heuristics require many specific decision parameters, and are often specifically fixed to particular types of decisions (e.g., only framed decisions; Brandsttatter et al., 2006). Although such heuristics may be effective in explaining choice behavior under specific constrained situations, they generally fail in explaining behavior across various contexts, or in situations where only incomplete information is available (known as overfitting; Todd & Gigerenzer, 2000). However, decision-makers often have to make decisions across various domains and in situations with incomplete decision information. Therefore, an effective decision-making heuristic must balance environmental specificity with domain-generality.

Need-based decision-making as specified by risk-sensitivity theory is a heuristic approach that accomplishes this balance. Decision-makers must acquire environmentally specific information about decision options (i.e., mean and variance of outcomes obtained through implicit learning), and must simply choose an option that is likely to meet their needs in a particular domain. This heuristic is able to effectively explain choice behavior in myriad domains, from foraging (Kacelnik & Bateson, 1996, 1997), to mate choice (Baker & Maner, 2008), to status-seeking behavior (Ermer, Cosmides, & Tooby, 2008; Hill & Buss, 2010). Thus, need-based decision-making fulfills the goal of elucidating a mechanism of decision-making under risk that is able to explain choice in both human and non-human animals across various domains.

Summary

Various theories of decision-making under risk have been developed in disparate fields. However, little attempt has been made to integrate these different theories and find common explanatory ground. This review and integration suggests that various influential theories of decision-making under risk share some important features, and can be unified under a normative framework conceptualizing utility as a measure of proxies of fitness. Although expected utility theory and prospect theory remain influential theories of decision-making under risk, more effort must be invested to try and contemporize these theories with a modern understanding of behavioral motivations shaped by evolution by natural selection. In this sense, risk-sensitivity theory serves as an excellent starting point for a theory of decision-making under risk, in that it explicitly acknowledges the pursuit of proxies of fitness and provides a simple ecologically relevant mechanism to describe decision-making.

To summarize the key points of the integrated model of decision-making under risk described in this chapter:

(1) Decision-makers do not explicitly seek to maximize fitness itself, but rather, seek to maximize goals that have been historically correlated with fitness, such as resource holding potential, social status, and mating opportunities.

(2) Maximization of proximate goals associated with fitness is relative. Instead of seeking to maximize absolute outcomes in various evolutionarily relevant domains, decision-makers seek to maximize the probability of meeting their needs in these domains.

(3) The perception of need is derived from various sources. An individual's present physiological or psychological state and the relative condition and possessions of others play a role in determining need perception in various domains.

(4) Need as derived from embodied capital and various environmental circumstances can explain commonly observed patterns of risk-taking, including individual differences in risk-preference (based on age, sex, and environmental circumstances) and the generality of risk-taking across various domains.

(5) Mood and cognitive biases play an important role in decision-making. Specifically, loss-aversion (partially facilitated by the amelioration of negative moods and disproportionate sensitivity to costs) and cognitive mechanisms such as the negativity bias are consilient with decision-making motivated by conditions of need.

(6) If utility is defined by proxies of fitness, and fitness is maximized by meeting one's needs in evolutionarily salient domains, then both expected utility theory and prospect theory make similar predictions about decision-making behavior as risk-sensitivity theory.

(7) Decision-making designed to maximize the probability of meeting one's needs is compatible with the notion of ecological rationality. Specifically, need-based decision-making employs cognitive mechanisms that are sensitive to the structure of information in the environment, and are simple enough to allow for generalization.

Although this model was conceived based on evolutionary considerations, need-based decision-making can be generalized to non-biologically relevant domains by virtue of its general simplicity. If, in any domain, a decision-maker finds themselves at disparity between their present state and desired state (i.e., a condition of need), they should choose whatever behavioral option that allows them to meet their need. In this sense, any underlying motivation that creates a sense of need may motivate risk-sensitive decision-making.

Furthermore, this model emphasizes that risk-taking is not necessarily irrational, reckless, or pathological, as it is typically conceived. Everybody engages in risk-taking to some degree. The model proposed in this paper suggests that risky behavior is, in fact, an adaptive response to certain environmental circumstances. This approach has some important implications. Utilizing an evolutionary approach—where risk-taking is conceived as potentially adaptive under some circumstances—may lead to a more productive understanding of the causes of, and solutions to, such societal issues as crime, gambling, and other forms of harmful risky behavior. Specifically, aiming to affect modifiable environmental causes of risk-taking may lead to significantly lower rates of various forms of harmful risky behavior. Future research should be informed by a more integrated and interdisciplinary approach to understanding decision-making under risk.

Figure 2.1.

Risk-indifferent (A), risk-averse (B), and risk-prone (C) utility curves. F represents a fixed option, and S and L represent the small and large potential gains of a variable option (adapted from Kacelnik & Bateson, 1998).

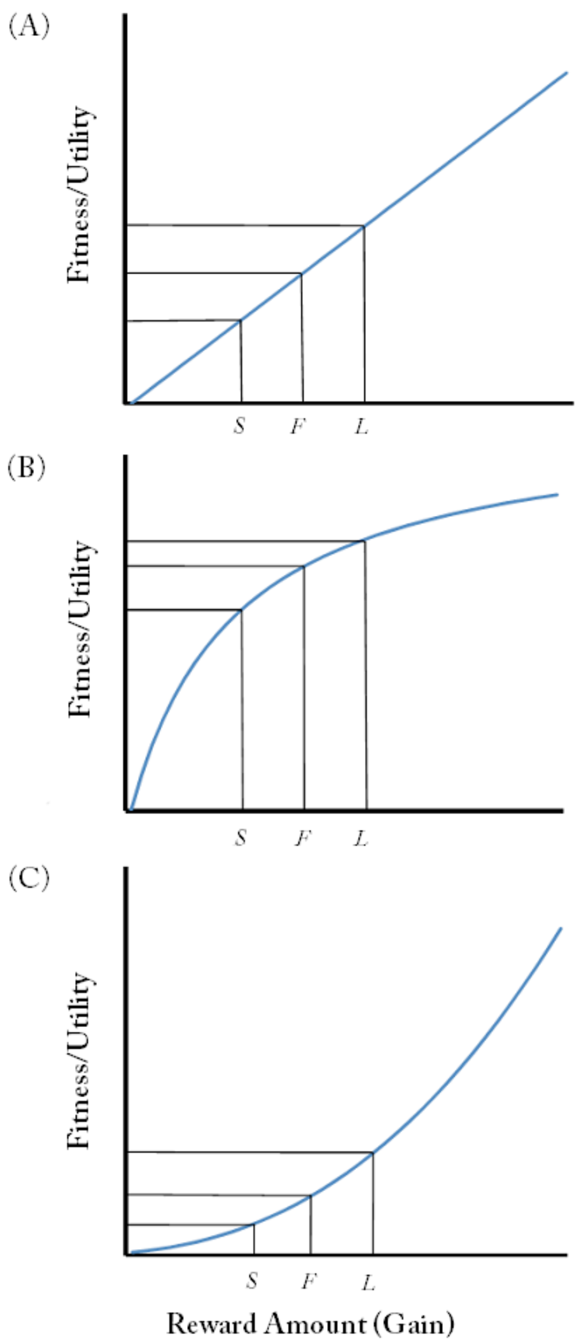
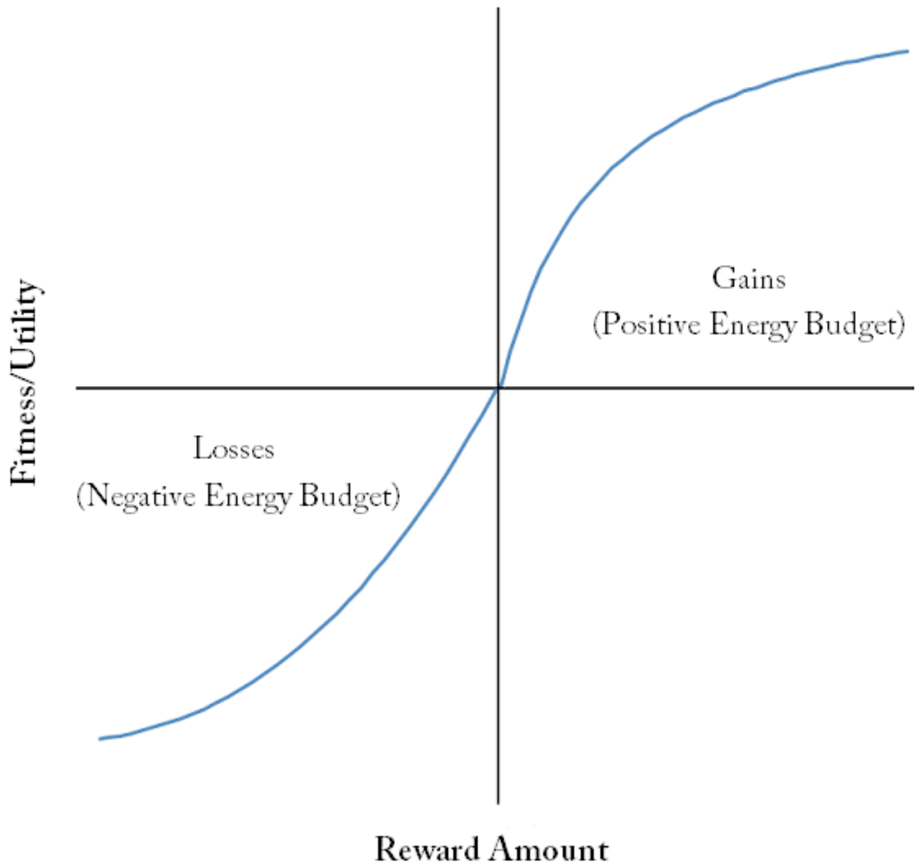


Figure 2.2.

Fitness/utility curve predicted by prospect theory (adapted from Kahneman & Tversky, 1979).



CHAPTER THREE

Individual Differences in Risk-Propensity: Associations Between Personality and Behavioral Measures of Risk

Abstract

Previous research has demonstrated that various forms of risky behavior are highly associated among individuals, and such personality traits as impulsivity, sensation-seeking, and low self-control are correlated with risky behavior. However, little evidence indicates that self-report measures of personality traits associated with risky behavior actually correlate with a behavioral preference for risk. In this study, we examined whether personality questionnaire measures of traits associated with risk (i.e., impulsivity, sensation-seeking, low self-control) are correlated with behavioral measures of risk (i.e., future discounting, probabilistic decision-making under risk tasks). We show that various measures of risk-propensity appear to comprise three principal components: Future Discounting, Risky Personality, and Variance Preference. Risky Personality and Variance Preference were significantly correlated. Future Discounting was not associated with either of the other risk components. Together, the results support the hypothesis that stable personality traits such as impulsivity, sensation-seeking, and low self-control represent proximate mechanisms through which a behavioral preference for risky outcomes manifests.

Introduction

Several theories suggest that various forms of risky behavior should be highly associated. Gottfredson and Hirschi (1990) argued that individuals who exhibit low self-control—a preference for immediate rewards at the cost of possible long-term negative consequences—tend to engage in a variety of risk-taking behaviors. They further suggested that low self-control gives rise to what they called the "generality of deviance", where low self-control combined with opportunity accounts for most, if not all, risky and criminal behavior (Hirschi & Gottfredson, 1994). Jessor's (1991) problem-behavior theory suggests that a balance of instigations (e.g., peer modeling) and controls (e.g., parental monitoring) determine the degree to which individuals engage in a "syndrome" of problem behaviors including substance use, delinquent behaviors, risky driving, and early sexual intercourse. Daly and Wilson (2001) suggested that various risky behaviors are similar products of decision-making processes designed to solve problems that arise in certain environments.

These theories are supported by substantial evidence suggesting that various forms of risky behavior, including crime, substance use, risky driving, early sexual intercourse, sexual coercion, gambling, delinquency, and antisocial behavior tend to co-occur both within individuals and at the aggregate level (Bartusch, Lynam, Moffitt, & Silva, 1997; Donovan & Jessor, 1985; Hirschi & Gottfredson, 1994, Leblanc & Girard, 1997; Lussier, LeBlanc, & Proulx, 2005; Mishra & Lalumière, 2009; Mishra, Lalumière, Morgan, & Williams, 2010; Mishra, Lalumière, & Williams, 2010; Osgood, Johnston, O'Malley, & Bachman, 1988). Furthermore, individuals who regularly engage in various forms of risk-taking (including gambling and crime) score higher than others on measures of poor self-control, impulsivity, and sensation-seeking (reviewed in Zuckerman, 2007). If such personality traits as self-control, impulsivity, and sensation-seeking are associated with general risky behavior, then high levels of such traits should necessarily be significantly associated with a behavioral preference for risk in laboratory tasks.

Personality Traits Associated with Risk-Taking

Several self-report instruments have been developed to measure risk-propensity. Such personality traits as sensation-seeking, impulsivity, and self-control have been consistently associated with real-world risky behavior in various domains (Samuels, Bienvenu, Cullen, Costa, Eaton, & Nestadt, 2004; White, Moffitt, Caspi, Bartusch, Needles, & Stouthamer-Loeber, 1994; Zuckerman, 2007). Sensation-seeking describes a willingness to engage in various activities in order to obtain varied, stimulating experiences (Zuckerman, 1994). Impulsivity describes a tendency to prefer short-term gains, without planning or forethought, with the potential for immediate or future costs (Eysenck, Pearson, Easting, & Allsop, 1985). Self-control is similar to impulsivity, in that low self-control is associated with a tendency to focus on temptations of the moment and ignore long-term consequences (Marcus, 2003). Other self-report instruments measure risk-propensity more directly, by having participants rate the likelihood of participation in various risky activities in different domains (e.g., the Domain Specific Risk-Taking Scale; Weber, Blais, & Betz, 2002).

Behavioral Measures of Risk

Self-report measures of personality traits associated with risk are contrasted with behavioral measures of risk-propensity, in which respondents make choices in the laboratory between alternatives and directly experience the outcome. Many behavioral measures of risk-propensity reflect a definition of risk as outcome variance, where the riskier of two options with the same expected value is that with higher outcome variance. For example, choosing a

10% chance of earning $30 over receiving $3 guaranteed would be a risky decision. These measures have been more frequently used in experimental situations where researchers measure changes in risk-propensity following an experimental manipulation (e.g., Daly & Wilson, 2001; Fessler, Pillsworth, & Flamson, 2004; Mishra & Lalumière, 2010). This use of behavioral measures of risk suggests that these measures may tap into more state-dependent risk-propensity than self-report personality measures. However, little research has examined the relationship of behavioral measures of variance preference and personality traits associated with risk-taking.

Future discounting, or delay discounting, is another behavioral measure of risk-propensity that has been widely used. Future discounting measures present participants with choices between imminent smaller monetary rewards and delayed larger rewards (e.g., a choice between receiving $45 immediately, or $75 in 30 days; Kirby, Petry, & Bickel, 1999). People who discount the future tend to choose imminently available rewards. Future discounting measures have been previously described as behavioral measures of impulsivity (e.g., Reynolds, Ortengren, Richards, & de Wit, 2006). As with behavioral measures of variance preference, future discounting measures have also been used largely as state-dependent measures (e.g., Wilson & Daly, 2004).

Personality and Behavioral Preferences for Risk

Most research that has examined the relationship between different measures of risk-propensity has focused solely on inter-relationships between self-report and behavioral measures of impulsivity, not risk more generally conceived, with inconsistent results. Ostaszewski (1996) found that people who exhibited steeper discounting of delayed rewards scored higher on impulsive personality. Other studies have similarly found that impulsive populations engage in higher levels of future discounting (reviewed in Daly & Wilson, 2006). Reynolds et al. (2006) found that several self-report measures of impulsivity correlated highly amongst each other, but were not significantly associated with behavioral measures of impulsivity. Based on these findings, Reynolds et al. suggested that self-report and behavioral measures of impulsivity likely measure different constructs.

White et al. (1994) suggested that poor measurement of the construct of impulsivity has contributed to inconsistent relationships between impulsivity and other traits and behaviors of interest. We similarly suggest that unclear and inconsistent measurement of the more general construct of risk-propensity may also contribute to misleading results. Personality traits such as impulsivity, sensation-seeking, and low self-control are consistently associated with various forms of real-world risk-taking (reviewed in Zuckerman, 2007). Laboratory-based behavioral measures of risk-propensity should therefore be correlated with personality traits associated with risk such as impulsivity, sensation-seeking, and low self-control.

Many risky behaviors are the products of immediate environmental influences (e.g., conditions of need; Mishra & Lalumière, 2010a). However, personality traits may lead people to behave in consistently risk-accepting or risk-averse manners at a baseline level, or may lead people to more often encounter conditions that facilitate risk-taking. If personality traits represent stable proximate mechanisms through which a baseline preference for risky outcomes manifests, then variability in personality traits associated with risk should be associated with actual behavioral tendencies to choose riskier outcomes.

In the present study, we (1) investigated the inter-relationships of several widely used personality and behavioral measures of risk-propensity, (2) determined whether there are distinct components underlying various types of risk measurement, and (3) examined whether components describing behavioral preferences for risk and personality associated with risk-acceptance were associated. We predicted that (1) various measures of risky personality and risk-acceptance would be correlated, (2) distinct components would describe personality traits associated with risk and behavioral preferences for risk, and (3) these two components would be significantly correlated.

Method

Participants

This study comprised two phases. In phase one, 240 participants (120 men), age 18-25 (M = 20.3±1.9) were recruited from undergraduate psychology classes and completed measures of personality associated with risky behavior (sensation-seeking, impulsivity, and self-control). All of the variables were normally distributed. Missing values were replaced for sensation-seeking (n = 3), impulsivity (n = 1), and self-control (n = 1) using the appropriate series means. We conducted a principal components analysis without rotation on these measures. A single principal component, labeled *risky personality*, explained 66.4% of the variance (KMO = .69). All measures on this factor loaded highly (>.70) and positively. This factor was used to select participants for the second phase of the experiment, which began a week later. We note that scatterplots were used to examine linearity and homoscedasticity for all principal components analyses, with no obvious deviations from assumptions observed.

Scores on the risky personality component were used to select participants for phase two of the study. Phase two participants were 58 men and 57 women (age: M = 20.0, SD = 2.0), consisting of those phase one participants scoring highest (20 males, 19 females), lowest (19 males, 23 females), and in the middle (19 males, 15 females) of the sex-relevant distribution of risky personality, consistent with a within-sex extreme-groups design. This design was used to maximize variance on measures of interest (Preacher, Rucker, MacCallum, & Nicewander, 2005).

Measures

Personality

Zuckerman's Sensation Seeking Scale (SSS-V). The Sensation Seeking Scale, Version 5 consists of 40 choices between pairs of statements regarding 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"; Zuckerman 1994). A total sensation-seeking score was obtained by summing the number of high sensation-seeking choices.

Eysenck's Impulsivity Scale (EIS). The EIS (Eysenck et al., 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.

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 (e.g., "I copied homework from classmates"), adolescence ("I have been late for school or work because I stayed out too late the night before"), and adulthood (e.g., "I have been caught in a speed trap"). 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; a higher score indicated lower self-control.

Domain-Specific Risk Taking Scale (DOSPERT). The DOSPERT (Weber et al.,

2002) is a self-report measure of the likelihood of engaging in risky behavior in five domains: financial (e.g., "Betting a day's income at a high stake poker game"), health/safety (e.g., "Not wearing a helmet when riding a motorcycle"), recreational (e.g., "Going whitewater rafting during rapid water flows in the spring"), ethical ("Having an affair with a married man or woman"), and social risky behaviors (e.g., "Arguing with a friend about an issue on which he or she has a very different opinion"). Participants rated the likelihood of engagement in each behavior from a scale of 1 (extremely unlikely) to 5 (extremely likely).

Behavioral Measures of Risk

Choice task (CT). Participants made six decisions, each between two monetary options (adapted from Fessler et al., 2004; Mishra & Lalumière, 2010). Both options had equal expected values but differed in variance (e.g., "Would you rather choose [A] $3 guaranteed, or [B] a 30% chance of earning $10?"). After task completion, participants rolled a die and received the value of one of the six choices they made (corresponding to the number on the die). A total score of number of risky choices was computed.

Balloon Analogue Risk Task (BART). Participants saw a computer screen with a deflated balloon and a "PUMP" button. Each pump of the balloon increased participants' earnings by one cent, and increased the degree to which the balloon was inflated. The balloon was set to pop randomly, with 65 pumps required on average before popping. If the balloon popped, participants lost all money gained for that trial. Participants could end a trial at any time by clicking on a "COLLECT" button. Thirty trials were presented. The first five trials were excluded from analysis as training. The average number of pumps for all trials where the balloon did not pop was computed (Lejuez et al., 2002).

Variance preference task (VPT). Participants chose between two options (Rode, Cosmides, Hell, & Tooby, 1999). The first option involved two possible choices: (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. The second option offered "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 binary score of risky/not-risky was used.

Future discounting I (FD). Participants were presented with a series of 21 choices between an amount of money available today, and an amount of money available in the future (Kirby et al., 1999). Choices were either for small, medium, or large amounts of money (seven in each category). At the end of this task, participants picked one of 21 ping-pong balls labeled from 1 to 21, and earned the amount of their choice in the form of cheque (either immediately cashable, or post-dated to the relevant future date). The dependent measure consisted of a discounting parameter (k) for each of small (FD_S), medium (FD_M), or large rewards (FD_L), calculated as described in Kirby et al. (1999). Higher discounting parameters indicated a greater preference for immediate rewards over later rewards.

Future discounting II (FDII). At the end of the experimental session, participants were offered the opportunity to either collect their total earnings immediately, or delay total earnings collection by three weeks and collect an additional $10 (Marcus, 2003). A binary discounting score (discounted, not discounted) was used.

Procedure

Phase one participants filled out paper versions of the personality measures (SSS-V, EIS, RBS) in small groups. Phase two participants were tested at individual computer stations, and completed the DOSPERT along with all behavioral measures. 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 were presented in random order. Average earnings were $44.38 (*SD*: $22.54, *Range*: $10.75 to $106.50).

All data were normally distributed, except for the BART and the future discounting I measures (FD_S, FD_M, FD_L). These measures were normalized using logarithmic transformations. FDII and VPT were nominal variables; non-parametric statistics were used where possible. Missing values (n = 1 for RBS, EIS, SSS, DOSPERT; n = 2 for SSS, FD_M, FD_L; n = 4 for FD_S) were imputed with the series mean. No outliers were detected.

Results

Inter-Relationships Between Measures of Risk-Propensity

The correlation matrix for all personality and behavioral measures of risk-propensity is presented in Table 3.1. Personality measures associated with risk-propensity were highly and significantly inter-correlated. Behavioral and future discounting measures were inconsistently inter-correlated amongst themselves and with risky personality traits. Males scored higher than females on all measures. Significant sex differences were obtained for all measures except for CT, FD_S, FD_L, and FDII. Fisher's *Z*-tests indicated that correlation magnitudes significantly differed between men and women for only two of 55 comparisons. After Bonferroni correction for multiple comparisons, no significant differences remained. As a result, data from men and women were combined for all subsequent analyses.

The Component Structure of Measures of Risk-Propensity

If different measures of risk-propensity assess a similar underlying construct of risk, a single factor should underlie all personality and behavioral measures of risk. A confirmatory factor analysis using a maximum likelihood procedure was conducted to test whether a one-factor model could adequately account for the underlying variance in risk measures. A goodness-of-fit test indicated that a one-factor model did not adequately account for variance in measures of risk, $\chi^2(44) = 200.42$, $p < .001$ (KMO = .72).

An exploratory principal components analysis was used to examine if there were a small number of principal components underlying the measures of risk-propensity. Three principal components with eigenvalues greater than 1.0 were extracted and rotated using a promax (*kappa* = 4) rotation procedure (allowing for factors to be correlated but interpretable; Table 3.2). These three principal components were labeled Future Discounting (PC1), Risky Personality (PC2), and Variance Preference (PC3). These three components explained 28.4, 23.0 and 10.7 percent of item variance respectively (62.1 percent total; KMO = .72). FDII was correlated with other self-report personality measures and loaded highly on the Risky Personality principal component.

Inter-Relationships Between Risk Components

Pearson correlations were used to investigate the relationship between the three principal components, with one significant result emerging: Risky Personality and Variance Preference was significantly and positively correlated, $r = .217$, $p = .01$ (one-tailed). Future Discounting was not significantly associated with Risky Personality, $r = .109$, $p = .13$, or with Variance Preference, $r = -.095$, $p = .16$ (both one-tailed).

Discussion

Results indicate that various common instruments of risk-propensity may measure different components of risky behavior. Three principal components explained a substantial amount of variance in measures of risk-propensity: Future Discounting, Risky Personality, and Variance Preference. Variance Preference and Risky Personality were significantly correlated, suggesting that there is an association between a behavioral preference for risk and higher levels of such personality traits as sensation-seeking, impulsivity, and low self-control. Future Discounting was unrelated to other measures of risk-propensity, suggesting that it may represent a separate construct from behavioral preferences for risk. Together, the results are supportive of the hypothesis that stable personality traits such as impulsivity, sensation-seeking, and low self-control represent proximate mechanisms through which a baseline behavioral preference for risky outcomes manifests.

Future discounting and impulsivity both reflect a tendency to prefer immediate rewards over later rewards. Several studies have demonstrated a link between future discounting and individual differences in personality, but have mostly done so in populations that exhibit high baseline levels of impulsivity (Bickel, Odum, & Madden, 1999; Kirby et al., 1999; Kollins, 2003; but see Daly & Wilson, 2006). We found an inconsistent relationship between future discounting and impulsivity. These results suggest that among university students, these two instruments might measure different constructs, a hypothesis supported by similar findings in other studies (Daly & Wilson, 2006; Reynolds et al., 2006). Different manifestations of a preference for immediate rewards may have different causes; Daly and Wilson (2006), for example, suggested that risk-preference may be mediated by variable attitudes toward the future, differences in the estimate of the utility of rewards, or the degree of risk involved in a reward. Further study of the nature and measurement of time preference and its relationship to impulsivity and general risk-propensity is required.

The component structure of measures of risk-propensity obtained in this study may be in part due to shared method variance. All of the personality instruments were self-report measures collected on paper, and all of the behavioral measures of risk were collected on a computer and involved choices that had real monetary consequences. The self-report and behavioral measures were also administered one week or more apart. Is it possible that self-report instruments of risk-propensity measure stable individual differences associated with tendencies to take risks, and behavioral measures of risk are more state-dependent. That there was a significant association between Risky Personality and Variance Preference, however, suggests that personality traits do influence immediate behavioral choices to engage in risky behavior to some degree. Because of shared method variance, this association may have in fact been underestimated in the present study.

The sample size used in this study was modest. However, we maximized variance in measures of interest by utilizing an extreme-groups design, which demonstrably increases statistical power in situations with constrained variability in measures of interest (Preacher et al., 2005). Furthermore, our principal components analyses reflected subjects-to-variables ratios of greater than 10:1, more than meeting the threshold for interpretable results (e.g., Velicer & Fava, 1998).

Another limitation involved the measures chosen for inclusion in this study. Although there are other measures available for personality traits associated with risk (e.g., Barratt Impulsiveness Scale; Patton, Stanford, & Barratt, 1995), the measures used in this study represent some of the most widely used, highly validated measures available, and thus, we chose them over others (Marcus, 2003; Zuckerman, 1994; Zuckerman, 2007). We do note, however, that several studies have demonstrated that there are several facets to such constructs as impulsivity, involving various different measurement instruments (e.g., Dick et al., 2001; Smith et al., 2007). As a consequence, there may be several different personality pathways to impulsive or risky behavior (e.g., Smith et al., 2007). Future research should examine the relationship of the various identified sub-facets of impulsivity with other personality traits associated with risk and behavioral measures of risk propensity.

Although we used an extreme-groups research design, it is possible that variability among traits of interest was constrained in our undergraduate sample. Future studies should investigate the relationships of various risk measures among populations that are known to exhibit high levels of risk-acceptance (e.g., young males, gamblers). The relationship among different risk measures may be very different among populations with higher levels of baseline risk-acceptance (although we note that this was not the case with regard to gender in the present study). Future studies should also compare the predictive validity of these components of risk by examining objective measures of risk (or outcomes of risk), such as delinquency records, school suspensions, or driving incidents. The stability of these risk measures is also an open question; it is presently unclear whether risk-acceptance is largely contingent on environmental circumstances, or whether individual differences in risk-acceptance are relatively stable over time and situation. It is apparent, however, that different measures of risk-acceptance appear to measure different aspects of risk, indicating that researchers should exercise caution when choosing and interpreting measures of risk-propensity in future studies.

Tables

Table 3.1.

Correlation matrix between personality measures associated with risk-propensity and behavioral measures of risk-propensity, including future discounting.

	EIS	RBS	DOS	VPT	CT	BART	FD_S	FD_M	FD_L	FDII
SSS	**.459**	**.491**	**.680**	.046	.119	**.154**	.096	.094	.091	**.240**
	(.00)	**(.00)**	**(.00)**	(.63)	(.20)	**(.10)**	(.31)	(.32)	(.33)	**(.01)**
EIS		**.541**	**.462**	.071	**.156**	.102	.088	.103	.100	**.253**
		(.00)	**(.00)**	(.45)	**(.10)**	(.28)	(.35)	(.28)	(.29)	**(.01)**
RBS			**.529**	-.023	.120	.049	.056	.072	.115	.140
			(.00)	(.81)	(.20)	(.61)	(.55)	(.44)	(.22)	(.14)
DOS				.091	.107	.159	.070	.102	.072	**.273**
				(.33)	(.26)	(.09)	(.46)	(.28)	(.44)	**(.00)**
VPT					.007	.138	.033	.134	**.154**	-.061
					(.94)	(.14)	(.73)	(.15)	**(.10)**	(.52)
CT						**.208**	.009	-.012	.057	.047
						(.03)	(.92)	(.90)	(.54)	(.62)
BART							**-.158**	**-.171**	**-.221**	.082
							(.09)	**(.07)**	**(.02)**	(.38)
FD_S								**.856**	**.820**	-.088
								(.00)	**(.00)**	(.36)
FD_M									**.873**	-.133
									(.00)	(.16)
FD_L										-.078
										(.41)

Notes: *P* values for each correlation are in parentheses. All tests are two-tailed Pearson *r*, except for those involving FDII and VPT (Spearman's *rho*). Significant and near-significant correlations ($p \leq .10$) are in bold. SSS = sensation seeking, EIS = impulsivity, RBS = low self-control, DOS = domain specific risk-taking scale, VPT = variance preference task, CT = choice task, BART = balloon analogue risk-taking, FD_S = small future discounting parameter, FD_M = medium future discounting parameter, FD_L = large future discounting parameter, FDII = future discounting II.

Table 3.2.

Factor loadings after Promax rotation; loadings above .40 are bolded.

	PC1 Future Discounting	PC2 Risky Personality	PC3 Variance Preference
FD_S	**.930**	.104	-.082
FD_M	**.965**	.144	-.070
FD_L	**.961**	.098	-.038
FDII	.134	**.437**	.129
SSS	.074	**.817**	.238
EIS	.100	**.752**	.192
RBS	.068	**.768**	.115
DOS	.068	**.848**	.264
VPT	.176	.074	**.451**
CT	.015	.149	**.628**
BART	-.258	.141	**.787**

Notes: See Table 3.1 for abbreviations.

CHAPTER FOUR

Gambling as a Form of Risk-Taking

Abstract

Substantial evidence suggests that various forms of risk-taking co-occur within individuals. We examined whether indicators of risk-propensity, including self-reported personality traits, laboratory-based behavioral measures of risk, and self-reported attitudes toward risk in various domains were associated with general gambling involvement and problem gambling behavior in a sample of university students, using an extreme-groups design. Personality traits and attitudes toward risk were associated with both problem gambling and general gambling involvement. Behavioral measures were positively correlated with general gambling involvement. Confirmatory factor analyses indicated that both problem gambling and general gambling involvement loaded on single factors with other measures of risk, suggesting that gambling represents one expression of a general propensity for risk-taking. Future study of the causes of gambling behavior may benefit from integration within a more general framework of risk-taking.

Introduction

Gambling involves an element of risk, typically a high probability of loss against a smaller probability of large gain. More generally, risky endeavors are those involving variable outcomes. Gamblers engage in such endeavors, exposing money not only to negative expected outcomes, but also to uncertain or variable outcomes. Some gamblers also subject other aspects of their lives to risky outcomes, sometimes jeopardizing their jobs or families to maintain a habit with negative returns. It is unclear whether gamblers have a general affinity for risky outcomes or whether their risk-preference is specific only to the gambling domain.

The Generality of Risk

Various forms of risky behavior, including substance use, dangerous driving, promiscuous sex, and delinquency, co-occur within individuals (reviewed in Mishra & Lalumière, 2009). Gambling may be part of this general pattern of risk-acceptance. Gambling has been associated with various forms of risky behavior (Martins, Tavares, da Silva Lobo, Galetti, & Gentil, 2004; Powell, Hardoon, Derevensky, & Gupta, 1999; reviewed in van Brunschot, 2009), and shares instigative factors associated with general risky behavior (reviewed in Stinchfield, 2004). If gambling is part of a broader constellation of risk-accepting behaviors, then various aspects of personality, decision-making tendencies, and attitudes associated with risky behavior should also be associated with gambling tendencies.

Personality and Risk-Taking

Such personality traits as sensation-seeking, impulsivity, and low self-control have been associated with risky behavior in various domains (reviewed in Zuckerman, 2007). Sensation-seeking describes a preference for varied, stimulating experiences and a willingness to engage in risk-taking in order to obtain such experiences (Zuckerman, 1994). Impulsivity refers to a tendency to prefer short-term rewards, without planning or forethought, with the potential for immediate or future costs (Eysenck, Pearson, Easting, & Allsop, 1985). Self-control, like impulsivity, is associated with a tendency to focus on temptations of the moment, ignoring long-term consequences (Marcus, 2003).

Impulsivity has consistently been associated with problem and pathological gambling (Blaszczynski, Steel, & McConaghy, 1997; Clarke, 2004; Franken, van Strien, Nijs, & Muris, 2008; Langewisch & Frisch, 1998; Myrseth, Pallesen, Molde, Johnsen, & Lorvik, 2009; Vitaro, Arsenault, & Tremblay, 1999). Sensation-seeking has been less consistently associated with gambling, with some studies suggesting problem gamblers exhibit higher levels of sensation-seeking (e.g., Cloninger, 1987), and others suggesting that problem gamblers may have lower levels of sensation-seeking (e.g., Powell et al., 1999; reviewed in Hammelstein, 2004). The relationship of low self-control and gambling has not received much attention so far; one study found that a self-control scale differentiated problem and non-problem gamblers, with problem gamblers exhibiting lower self-control (Corless & Dickerson, 1989). Factors implicated in temporary reduction of self-control have also been associated with increases in gambling and risk-taking behavior (Baron & Dickerson, 1999; Corless & Dickerson, 1989; Freeman & Muraven, 2010).

Behavioral Preferences for Risk

Several laboratory tasks have been developed as behavioral measures of risk-taking, including the Choice Task (Mishra & Lalumière, 2010a), the Balloon Analogue Risk Task (Lejuez et al., 2002), and the Variance Preference Task (Rode, Cosmides, Hell, & Tooby, 1999). In these tasks, scenarios are presented such that people's decisions reflect individual differences in risk-preference. Risk-preference as measured in laboratory settings has been associated with real-world risky behaviors, including addictive, health, and safety risk behaviors, risky sexual behaviors, substance use, and general delinquency (e.g., Lejuez et al., 2002; Lejuez, Aklin, Zvolensky, & Pedulla, 2003). These studies demonstrated that behavioral measures of risk explain additional variance in risk-taking above and beyond that accounted for by self-report personality traits such as impulsivity and sensation-seeking.

Attitudes Toward Risk

Attitudes toward risk may also play an important role in explaining gambling behavior. Risk-accepting attitudes have been correlated with such personality traits as sensation-seeking, impulsivity, and low self-control, and have been associated with self-reports of real-world risk-taking (Weber, Blais, & Betz, 2002). Instruments such as the Domain-Specific Risk Taking Scale (Weber et al., 2002) measure risk-accepting attitudes in various domains (e.g., financial, health, ethical, social, and recreational risk). Possessing risk-accepting attitudes in various domains may be associated with elevated gambling tendencies.

Overview

Personality traits associated with risk-acceptance, laboratory-based behavioral measures of risk, and attitudes toward risk have been correlated with various forms of real-world risky behavior. If gambling is a form of risk-taking, various measures of risk-propensity should be correlated with gambling behavior. We examined the relationship between gambling tendencies and personality traits associated with risk, behavioral measures of risk, and attitudes toward risk. We predicted that gambling tendencies would be significantly correlated with individual differences associated with non-gambling forms of risk-taking. Furthermore, we predicted that a one-factor solution should account for variance in gambling tendencies and individual differences associated with general risk-taking.

Method

Participants

This study comprised two phases. In phase one, 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 risk-taking (sensation-seeking, impulsivity, and self-control). The same participants were used in the study described in Chapter Three. Undergraduate students exhibit relatively high levels of gambling behavior (e.g., Engwall, Hunter, & Steinberg, 2004; Winters, Bengston, Door, & Stinchfield, 1998), thus representing an appropriate population in which to investigate the relationship between gambling and risk-taking.

We conducted a principal components analysis (PCA) without rotation on measures of personality associated with risk-taking (sensation-seeking, impulsivity, and self-control). A single component, *risky personality*, explained 66.4% of the variance (KMO = .69). All measures on this factor loaded highly (all >.70) and positively. Scatterplots were used to examine homoscedasticity and linearity for all PCAs, with no obvious deviations observed. Rotation was not used because of high intercorrelation among the three variables, increasing the likelihood of maximal variance being extracted without rotation. Similar results were obtained using an oblique rotation.

The risky personality component was used to select participants for the second phase of the experiment. Those phase one participants scoring highest (20 males, 19 females), lowest (19 males, 23 females), and in the middle (19 males, 15 females) of the sex-specific distribution of risky personality participated in phase two of the experiment, following a within-sex extreme-groups design. Phase two participants were 58 men and 57 women (age: *M* = 20.0, *SD* = 2.0). Participants comprised 65 non-problem gamblers (60.2%), 27 low-risk gamblers (25.0%), 15 problem gamblers (13.9%), and one pathological gambler (0.9%), as measured by the PGSI (described below).

Measures

Personality

Zuckerman's Sensation Seeking Scale (SSS-V). The Sensation Seeking Scale, Version 5 (Zuckerman, 1994), consists of 40 choices between pairs of antithetical statements about preferences for varied, stimulating experiences and disinhibited behavior. A total score was obtained by summing the number of high sensation-seeking choices.

Eysenck's Impulsivity Scale (EIS). The EIS (Eysenck, et al., 1985) consists of 19 yes/no statements about impulsive behaviors. A total score was obtained by summing the number of "yes" answers.

Retrospective Behavioral Self-Control Scale (RBS). The RBS (Marcus, 2003) measures behaviors across the lifespan 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 score was obtained by summing ratings of frequency of engagement in risky behavior. Higher scores indicated lower self-control.

Risk Attitudes

Domain-Specific Risk Taking Scale (DOSPERT). The DOSPERT (Weber et al., 2002) is a self-report measure of likelihood of engagement in 60 risky behaviors in seven content domains: gambling, investment, health/safety, recreational, ethical, and social (abbreviated D-G, D-I, D-H, D-R, D-E, and D-S, respectively). Behaviors were rated on a scale from 1 (*extremely unlikely*) to 5 (*extremely likely*). A total score was obtained by summing all of the items (D-T).

Behavioral Measures of Risk

Choice task (CT). Participants made six decisions, each between two monetary options (Mishra & Lalumière, 2010a). Both options had equal 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 (0 to 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 what each contains), 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 binary score of risky/not-risky was computed.

Balloon Analogue Risk Task (BART). Participants saw a computer screen with a deflated balloon and a "PUMP" button (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 (Lejuez et al., 2002).

Gambling

Problem Gambling Severity Index (PGSI). The PGSI (Ferris & Wynne, 2001) is a nine-item self-report measure of problem and pathological gambling behavior, based on behavior in the last 12 months. Engagement in various gambling behaviors were rated on a scale from 0 (*never*) to 3 (*almost always*). The PGSI categorizes an individual's gambling tendencies into one of four types: non-problem gambling, low-risk gambling, moderate problem gambling, and severe problem (pathological) gambling. For analysis, a continuous total score of 0 to 27 was used.

Gambling Involvement. Self-reports of (1) total number of different gambling activities engaged in, and (2) monthly frequency of gambling (both over the past year) were obtained (Williams & Connolly, 2006).

Procedure

Phase one participants completed paper questionnaires consisting of the personality measures in small groups. Phase two participants were tested individually at computer stations, and completed the behavioral measures and the gambling measures. After each task, participants called the experimenter to make any relevant draws and collect earnings, denoted with poker chips (making earnings tangible). Earnings were exchanged at the end of the session for a cheque. All questionnaires and tasks were presented in random order. Average earnings were $44.38 (*SD*: $22.54, *Range*: $10.75 to $106.50).

Results

Data Preparation and Reduction

All data were normally distributed, except for the BART, two DOSPERT subscales (social, gambling), PGSI, and days per month spent gambling. All data were normalized using logarithmic transformations, except for DOSPERT gambling and days per month spent gambling, which could only be normalized using inverse transformations. There were seven missing PGSI values. These participants were excluded from all relevant analyses. Other missing values (n = 1 for RBS, EIS, SSS-V, DOSPERT; n = 2 for SSS-V) were imputed with the series mean. Three outliers were detected for days per month spent gambling; these values were winsorized. Scatterplots were used to examine homoscedasticity and linearity for all PCAs; no violations were observed. To simplify subsequent analyses involving gambling tendencies, a composite variable, *general gambling involvement* (GGI), was computed by summing z-scores of the two gambling involvement behaviors.

Gambling and Risk-Acceptance

Descriptive statistics are provided in Table 4.1. Correlations between measures of gambling, personality traits, and behavioral measures of risk are shown in Table 4.2. Impulsivity, sensation-seeking, and low self-control were significantly associated with both problem gambling (PG) and GGI. Behavioral measures of risk were less strongly associated with gambling behavior. Correlations between measures of gambling and attitudes toward risk are shown in Table 4.3. PG was associated with risk-accepting attitudes in all domains except recreational and social risk. GGI was associated with risk-accepting attitudes in all domains except for social risk.

Men scored significantly higher than women on all raw and composite measures in this study, with the exception of the CT and the investment and social scales of the DOSPERT. Fisher's *Z*-tests indicated that correlation magnitudes significantly differed (ps $< .05$) between men and women for seven of 64 comparisons. After Bonferroni correction for multiple comparisons, however, no significant differences remained. Consequently, data from men and women were combined for all subsequent analyses.

The Structure of Risk and Gambling Measures

If gambling represents a manifestation of general risk-acceptance, a single factor should underlie all measures of risk and gambling. Two confirmatory factor analyses were conducted to examine whether PG and GGI loaded on single factors along with other measures of risk. Separate analyses were conducted for PG and GGI because they appear to comprise distinct patterns of gambling behavior (Williams, West, & Simpson, 2008).

Problem gambling. A goodness-of-fit test using the maximum likelihood procedure indicated that a one-factor model adequately accounted for the underlying variance in risk measures and PGSI, $\chi^2(20) = 18.06$, $p = .58$ (KMO = .78). PCA indicated that one factor explained 35.8% of the variance in measures of risk and PG (Table 4.4A).

General gambling involvement. A goodness-of-fit test using the maximum likelihood procedure indicated that a one-factor model adequately accounted for the underlying variance in risk measures and GGI, $\chi^2(20) = 25.30$, $p = .19$ (KMO = .76). PCA indicated that one factor explained 36.1% of the variance in measures of risk and GGI (Table 4.4B).

A goodness-of-fit test including both PG and GGI indicated that a one-factor model still adequately accounted for underlying variance in all measures, $\chi^2(27) = 38.89$, $p = .07$ (KMO = .75). PCA indicated that one factor explained 34.5% of variance in measures of risk and gambling.

Predicting Problem Gambling and General Gambling Involvement

PGSI and GGI scores were regressed on three blocks of variables (in order): personality traits associated with risk (SSS-V, EIS, RBS), behavioral measures of risk (CT, VPT, BART), and risk-accepting attitudes (DOSPERT subscales: investment, health, recreational, social, ethical, and gambling). The order of blocks was chosen such that established correlates of gambling tendencies, such as impulsivity and sensation-seeking, would be allowed to account for as much variance as possible in PG and GGI before other measures were allowed to do so. This hierarchical method allowed for quantification of the degree to which behavioral measures of risk and attitudes toward risk explained variance above and beyond established personality correlates of gambling.

Problem gambling. Personality traits associated with risk significantly predicted PG as measured by the PGSI, adjusted $R^2 = .13$, $p < .001$. The only significant individual predictor was low self-control, $\beta = .375$, $p = .001$. Behavioral measures of risk did not significantly add to variance explained in PG, R^2 *change* = .005, $p = .90$. Risk-accepting attitudes significantly added to the variance explained in PG, R^2 *change* = .13, $p = .01$, with attitudes toward gambling as the only significant predictor, $\beta = .342$, $p = .004$.

General gambling involvement. Personality traits associated with risk significantly predicted GGI (adjusted $R^2 = .11$, $p = .001$). The only significant individual predictor was impulsivity, $\beta = .220$, $p = .05$. Behavioral measures of risk marginally added to variance explained, above and beyond personality traits associated with risk, R^2 *change* = .05, $p = .10$. VPT was the only significant individual predictor, $\beta = .213$, $p = .02$. Risk-accepting attitudes also marginally added to variance explained in GGI, R^2 *change* = .09, $p = .06$, with no significant individual predictors.

Discussion

The results indicate that individual differences in personality traits associated with risk, behavioral preferences for risk, and attitudes toward risk are associated with gambling behavior. A single factor accounted for variance among all measures of risk and gambling tendencies. Regression analyses indicated that attitudes toward risk explained a significant amount of variance in gambling behavior above and beyond personality traits toward risk. Behavioral preferences for risk explained a marginal additional amount of variance above and beyond personality traits associated with risk. Together, the results provide support for the hypothesis that gambling is a form of more general risk-taking.

Personality and Gambling

Both PG and GGI were predicted by personality traits associated with risk. Sensation-seeking and impulsivity were not significant individual predictors of PG when self-control was included in a regression model. Impulsivity has been shown to be a robust predictor of problem PG (e.g., Blaszczynski et al., 1997; Clarke, 2004; Langewisch & Frisch, 1998). In the present study, however, impulsivity was not a significant predictor of PG when included in a regression with other measures of personality traits associated with risk. Rather, self-control was the best predictor of PG. Because impulsivity and self-control are similar constructs, it is possible that the relationship between PG and impulsivity may be a byproduct of a stronger relationship between PG and low self-control. A partial correlation between PG and impulsivity controlling for low self-control was not significant, $r = -.011$, $p = .91$, whereas a partial correlation between PG and low self-control controlling for impulsivity remained significant, $r = .340$, $p < .001$, suggesting that low self-control is an important, but understudied, personality trait associated with PG. Unlike PG, GGI was better predicted by sensation-seeking and impulsivity than self-control. A lack of self-control may lead to PG, whereas a more general preference for varied, stimulating experiences may lead to gambling behavior more generally (e.g., Langewisch & Frisch, 1998). Further research is required to better understand associations between impulsivity, self-control, and gambling behavior.

Attitudes Toward Risk

Beyond personality traits, additional variance in PG and GGI was explained by positive attitudes toward risk, especially specific attitudes toward gambling. Attitudes toward risk may therefore represent an important component of gambling behavior. Risk-accepting attitudes toward gambling were highly and significantly associated with risk-accepting attitudes in most other domains of risk, lending support to the notion that gambling-related attitudes are a component of more general risk-accepting attitudes. Attitudes toward risk have been largely unstudied in the context of gambling, and as such, future research should integrate attitude measures to better understand motivational mechanisms that may facilitate gambling behavior.

Behavioral Measures of Risk

A behavioral preference for risky outcomes was marginally associated with GGI, but not PG. Behavioral measures of risk tap into interest for variable outcomes, suggesting that non-problem gamblers may be attracted to the variability inherent in gambling outcomes. That a behavioral preference for risky outcomes was not associated with PG is puzzling, although it is somewhat consistent with previous findings (Vigil-Colet, 2007). Problem gamblers may be initially attracted to gambling due to the appeal of variable outcomes with high reward potential, but may maintain the behavior for other reasons, such as low self-control leading to an inability to resist further engagement in a self-defeating behavior. Increased arousal to positive outcomes, comorbid psychiatric disorders, gambling-related irrational beliefs, or other social or situational factors may also contribute to the maintenance of PG (reviewed in Williams et al., 2008).

Limitations

Two confirmatory factor analyses demonstrated that one-factor solutions effectively explained common variance in both forms of gambling and other measures associated with risk-propensity. The loadings on these factors were highest for personality traits associated with risk, risk-accepting attitudes, and the two gambling measures. A behavioral preference for risk did not load as highly on these two factors. Shared method variance may play a role in explaining these findings: In this study, all measures of risk-propensity, with the exception of behavioral measures of risk, were presented in questionnaire form.

Our sample was comprised of university students, a population that has been shown to exhibit high levels of gambling behavior (e.g., Engwall et al., 2004; Winters et al., 1998). We maximized variance on personality traits of interest by utilizing an extreme-groups approach, which demonstrably increases statistical power in situations with constrained variability in measures of interest (Preacher, Rucker, MacCallum, & Nicewander, 2005). Nevertheless, further study of individual differences and gambling behavior should utilize more diverse and representative populations of gamblers.

Other individual differences in personality have been implicated in the production of gambling behavior, including perfectionism, positive urgency, and the Big Five personality traits (e.g., Bagby et al., 2007; Brand & Altstotter-Gleich, 2008; Cyders & Smith, 2008). Future studies examining the association between individual differences in personality and gambling behavior should integrate a wider array of personality measures.

Conclusions

Both GGI and PG share common variance with various measures of risk-propensity. This finding, in addition to the positive correlations between personality traits associated with risk, risk-attitudes, and gambling, adds to a growing literature suggesting there are common determinants for gambling and risk-taking. Future research should integrate the measurement of individual differences in general risk-propensity with other established determinants of gambling (e.g., presence of an early win, parental gambling, ethnicity, proximity to gambling opportunities; Williams et al., 2008) in order to gain a better understanding of the various causal mechanisms underlying gambling behavior.

Tables

Table 4.1.

Descriptive statistics for gambling measures, personality traits associated with risk, and behavioral measures of risk preference (N = 115).

	Mean (Std. Dev.)	**Alpha**
Gambling Measures		
PGSI	.94 (1.5)	.63
GGI	.00 (1.9)	–
Personality Traits		
EIS	.39 (.21)	.78
SSS-V	.52 (.16)	.84
RBS	145.8 (50.9)	.95
Risk-Attitudes		
D-I	12.5 (3.3)	.70
D-G	6.1 (3.5)	.90
D-H	21.2 (5.5)	.66
D-R	26.1 (7.2)	.83
D-S	28.8 (4.5)	.58
D-E	16.8 (6.1)	.82
D-T	111.4 (20.7)	
Behavioral Measures		
VPT	.00 (1.0)	–
CT	2.1 (1.6)	–
BART	33.0 (15.0)	–

Notes. All means reported reflect untransformed, raw scores, except for the GGI composite measure. Attitudes toward investment (D-I), gambling (D-G), health (D-H), recreational (D-R), social (D-S), and ethical (D-I) risk are abbreviated. D-T = total risk-accepting attitude score; PGSI = problem gambling; GGI = general gambling involvement; EIS = impulsivity, SSS-V = sensation-seeking, RBS = low self-control, VPT = variance preference, BART = balloon analogue risk-taking, CT = choice task.

Table 4.2.

Correlations between gambling measures, personality traits associated with risk, and behavioral measures of risk preference (N = 115).

	GGI	EIS	SSS-V	RBS	VPT	BART	CT
PGSI	.433**	.207*	.240*	.393**	.032	.053	.106
GGI		.320**	.298**	.238*	.206*	-.001	.128
EIS			.459**	.541**	.052	.103	.156*
SSS-V				.491**	.055	.158*	.119
RBS					-.016	.052	.120
VPT						.142	.000
BART							.202*

Notes: See note for Table 4.1 for abbreviations. All tests are one-tailed (** = significant with Bonferroni correction; * = significant without Bonferroni correction; $\alpha = .05$).

Table 4.3.

Correlations between gambling measures and risk-attitudes (N = 115).

	D-I	D-G	D-H	D-R	D-S	D-E	D-T
PGSI	.204*	.413**	.312**	.139	.017	.371**	.359**
GGI	.196*	.368**	.318**	.179*	.093	.403**	.373**
D-I		.277**	.222*	.248*	.361**	.381**	.538**
D-G			.386**	.306**	.090	.495**	.573**
D-H				.516**	.321**	.619**	.801**
D-R					.290**	.346**	.738**
D-S						.290**	.549**
D-E							.783**

Notes: See note for Table 4.1 for abbreviations. All tests are one-tailed (** = significant with Bonferroni correction; * = significant without Bonferroni correction; $\alpha = .05$).

Table 4.4.

Results of PCAs on (A) problem gambling and risk measures, and (B) general gambling involvement and risk measures (N = 115).

(A) Measure	Loading	(B) Measure	Loading
SSS-V	.782	SSS-V	.800
EIS	.727	EIS	.743
RBS	.800	RBS	.744
D-T	.832	D-T	.831
VPT	.084	VPT	.164
CT	.261	CT	.268
BART	.195	BART	.240
PGSI	.531	GGI	.546

Notes. See Table 4.1 for abbreviations.

CHAPTER FIVE

The Motivational Effect of Need on Risk-Sensitive Decision-Making

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.

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 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 & Bateson, 1996, 1997; Weber, Shafir, & 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 1,000 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.

If someone is far from an acceptable threshold (e.g., low income, poor social status) he may do well to engage in risk-taking 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 exposing 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 & Kuhlman, 2001; Zuckerman, 2007), 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, 2004), 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., 2004). 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 examined and controlled for sex and other individual differences on risk-sensitive decision-making.

Method

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). The same participants were used in the studies described in Chapters Three and Four. 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.

Measures

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).

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.

Eysenck's Impulsivity Scale (EIS). The EIS (Eysenck et al., 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.

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.

Choice task (CT). Participants made six decisions, each between two monetary options (adapted from Fessler, Pillsworth, & Flamson, 2004). Both options had equal 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.

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.

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.

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.

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 × 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.

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: $M_{yield/day} = 7.3$; $SD_{yield/day} = 2.5$; Tree 2: $M_{yield/day} = 4.7$, $SD_{yield/day} = 2.5$). The other two trees had the same mean outcome, but different variance in outcome (Tree 3: $M_{yield/day} = 8.0$, $SD_{yield/day} = 6.0$; Tree 4: $M_{yield/day} = 8.0$, $SD_{yield/day} = 0.9$).

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 (and 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 by choosing the high risk option*. 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.

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 to $106.50).

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 5.1). Descriptive statistics are shown in Table 1; all means presented are unadjusted. All analyses were conducted using SPSS version 17.0.0.

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, $r = .88$, $p < .001$ (Figure 5.1).

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. 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.

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, $r = .59$, $p < .001$ (Figure 5.2).

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

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.

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, $M_{men} = .73$, $M_{women} = .67$, $t(54) = .569$, $p = .57$, $r = .08$.

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 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 extreme-group approaches, including issues of statistical power, effect size, and reliability (Preacher, Rucker, MacCallum, & Nicewander, 2005). We attempted to alleviate potential problems associated with an extreme-groups approach 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 proxies 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).

Tables and Figures

Table 5.1.

Descriptive statistics and sex differences for individual differences measures.

	Male		*Female*		*Sex Difference*	
Measure	*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.

Figure 5.1.

Correlation between the probability of meeting one's need and actual decisions in VPN. Points represent mean decision choice over all participants for each of the 20 decisions constructed from the four different bead ratios and five levels of need.

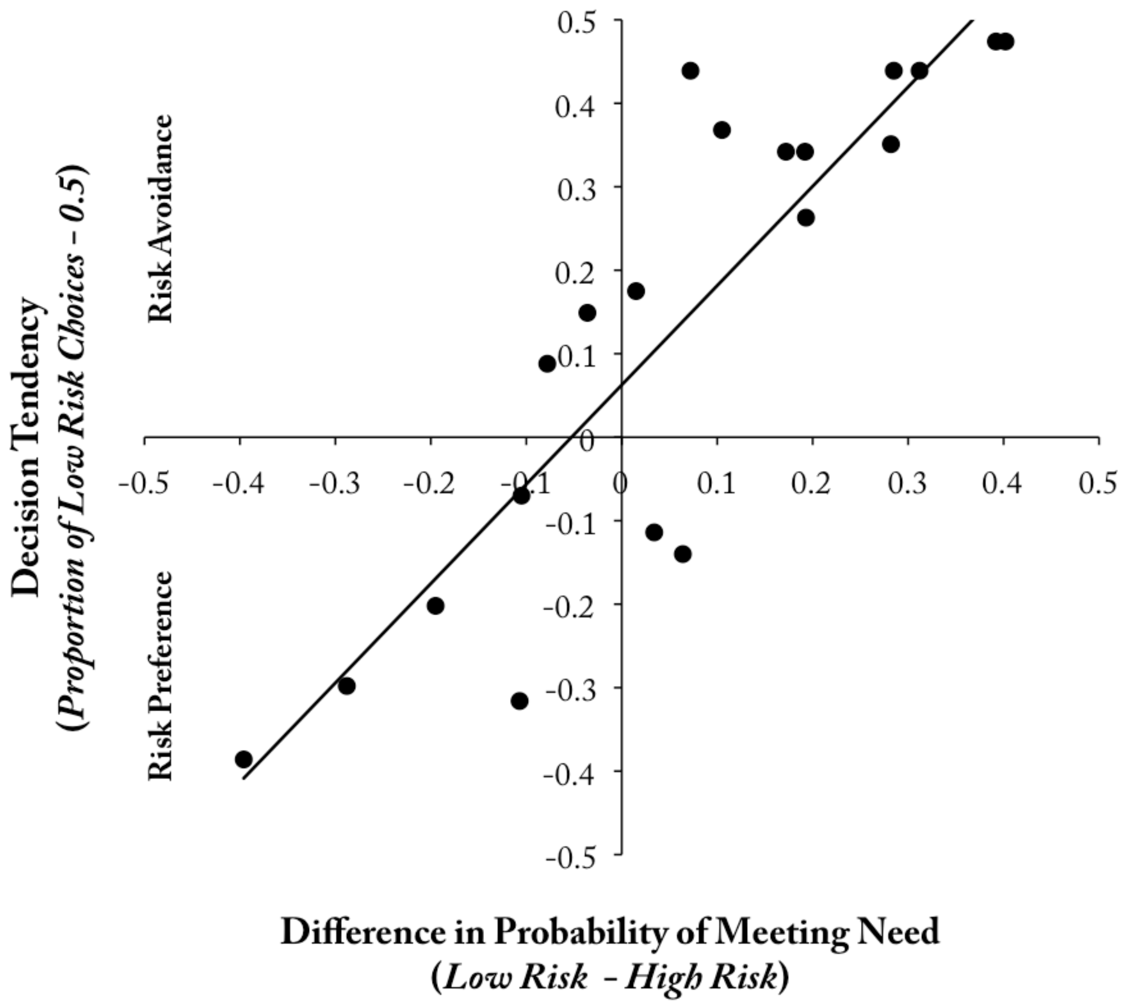
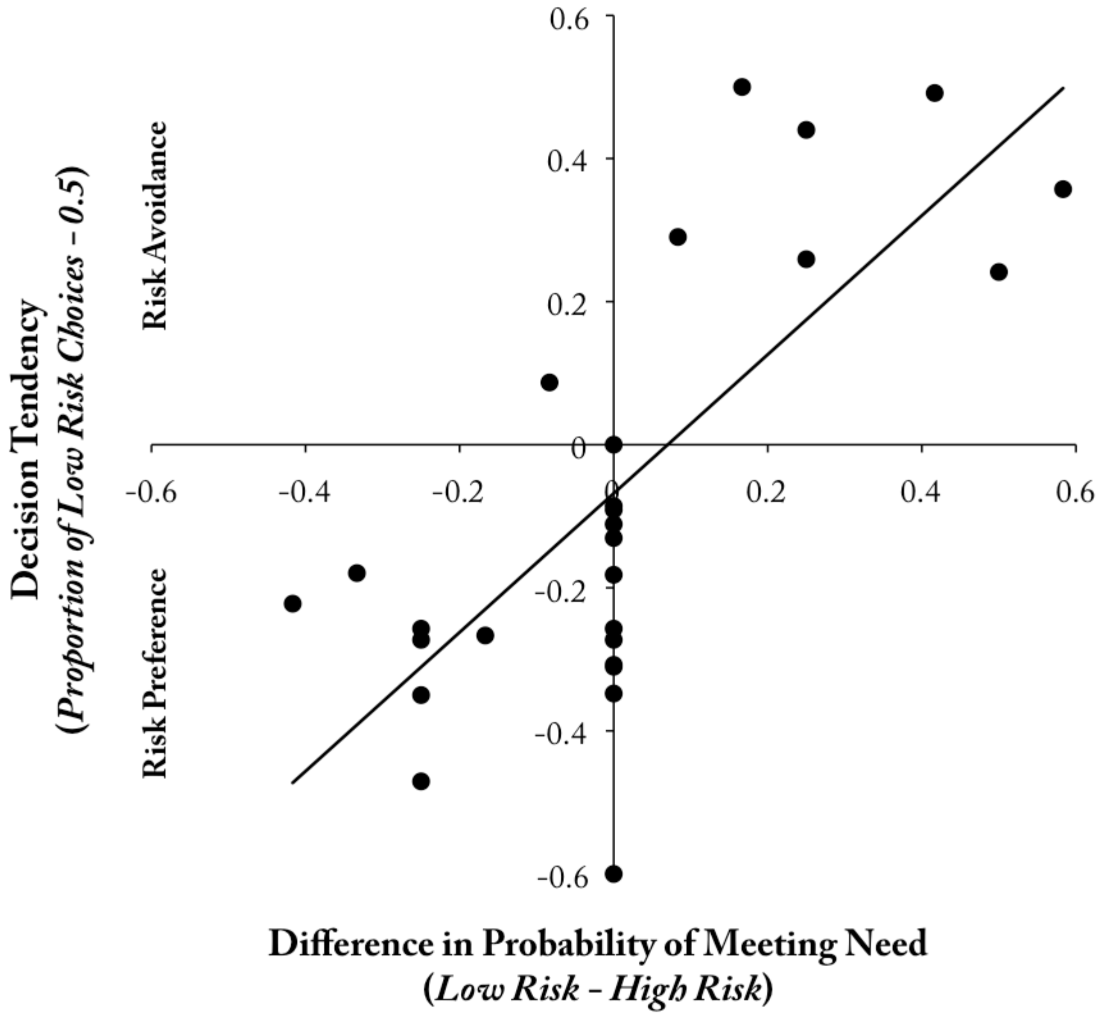


Figure 5.2.

Correlation between the probability of meeting one's need and actual decisions in the ECO. Points represent mean choice over 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).



CHAPTER SIX

Inequality and Risk-Taking

Abstract

Income inequality has been associated with various forms of risky behavior at the aggregate level, including teenage pregnancy, violence, substance abuse, and crime. Little experimental research, however, has examined whether there is a causal link between inequality and risky decision-making. In four experiments involving 345 young men and women, we examined whether people exhibit higher risk-acceptance after experiencing inequality manifesting through structural means or competitive disadvantage. Results indicate that both systemic inequality and competitive disadvantage appear to play a causal role in motivating risk-taking. The experience of inequality elevated risky choice, and removal of the experience of inequality decreased risky choice. Results were obtained controlling for individual differences in risk-propensity and sensitivity to justice violations. These findings represent the first experimental evidence demonstrating that inequality causes risk-taking.

Introduction

Risk-sensitivity theory predicts that decision-makers shift from risk-aversion to risk-proneness in situations of high need, where need describes disparity between an individual present state and a goal (or desired) state. Someone with a $500 debt, for example, should prefer a 10% of winning $500 over receiving $50 with certainty. Risk-sensitivity theory has received substantial empirical support in the non-human animal literature (reviewed in Kacelnik & Bateson, 1996), and has been increasingly supported in recent human studies (Deditius-Island, Szalda-Petree, Kucera, & 2007; Mishra & Fiddick, 2010; Mishra, Gregson, & Lalumière, 2010; Mishra & Lalumière, 2010a; Pietras & Hackenberg, 2001; Pietras, Locey, & Hackenberg, 2003; Rode, Cosmides, Hell, & Tooby, 1999; Wang, 2002).

Mishra and Lalumière (2010a), for example, showed in an experimental study that people made significantly more risky, high variance choices under induced conditions of high need, where they were far from a desired outcome. Under induced conditions of low need, participants did not expose themselves to the unnecessary possibility of not meeting their needs, choosing low-risk options with low variance in payoff more frequently. These results were obtained both with and without controlling for sex and individual differences, suggesting that this pattern of decision-making is robust and consistent.

One particularly salient form of need is inequality. The experience of inequality represents a condition of high need: If someone is a victim of inequality, they are at distance from a desired state (i.e., the relative success of others). Substantial evidence suggests that people are particularly sensitive to relative disparity. For example, most people would prefer a smaller 2,000 square foot house in a neighborhood full of 1,000 square foot houses than a twice-as-large 4,000 square foot house in a neighborhood full of 6,000 square foot houses

(Frank, 2000). Relative outcomes should thus be privileged in risky decision-making, and the perception of need—disparity between one's present and desired state, where one's desired state is dictated by the state of others—captures this sensitivity to relative standing and inequality.

Income inequality has been reliably and strongly associated with various forms of risky behavior at the aggregate level, including teenage pregnancy, violence, substance use, and crime (reviewed in Wilkinson and Pickett, 2007, 2009). Substantial evidence has shown that the Gini Index of household income inequality predicts rates of homicide cross-nationally and across time (Avison & Loring, 1986; Blau & Blau, 1982; Kawachi, Kennedy, & Wilkinson, 1999; Kennedy, Kawachi, & Prothrow-Stith, 1996; Krahn, Hartnagel, & Gartrell, 1986; Wilkinson, Kawachi, & Kennedy, 1998; reviewed in Wilkinson & Pickett, 2009). Smaller scale analyses provide further support for an inequality-risk link: Wilson and Daly (1997) demonstrated that among Chicago neighborhoods, income inequality explained variance in homicide above and beyond that accounted for by other factors.

Although substantial evidence suggests that income inequality is associated with risky behavior at the aggregate level, little experimental research has examined the link between inequality and risk-taking. Greenberg (1993) demonstrated that pay equity was associated with stealing. Participants completed a clerical task, and were told that they would either receive the amount initially advertised as compensation for participation, or an amount less than that initially advertised. Participants were then given the opportunity to pay themselves from a change container. Those who were underpaid relative to expectations were more likely to steal an amount in excess of that which they were initially owed.

Similarly, the experience of relative deprivation—the perception that one is being deprived of a deserved outcome relative to others—has been associated with self-reported gambling urges: People who perceived themselves to be relatively deprived compared to others (through manipulation of supposed discretionary income), were more likely to opt to gamble when given the opportunity (Callan, Ellard, Shead, & Hodgins, 2008). Although evidence suggests that inequality is associated with theft and gambling, little research, to our knowledge, has examined whether inequality is associated with a more general increased preference for risky outcomes.

Inequality can take one of two forms: systemic inequality and competitive disadvantage. Systemic inequality describes inequality from extrinsic sources (e.g., discrimination based on race or socioeconomic status). Competitive disadvantage describes inequality derived from intrinsic sources. For example, an unattractive individual may perceive himself or herself to be at competitive disadvantage relative to other more attractive competitors. If the perception of need manifesting through inequality motivates risky behavior, then inequality of both forms should be associated with an increased preference for risky outcomes.

In four experiments, we examined whether inequality manifesting in the form of systemic inequality and competitive disadvantage affected risk-taking behavior. Experiments 1 and 2 examined whether systemic inequality and competitive disadvantage facilitated increased risk-taking behavior. Experiment 3 examined whether the effect of systemic inequality on risk-taking could be eliminated through amelioration of systemic inequality. Experiment 4 similarly examined whether the effect of competitive disadvantage on risk-taking could be eliminated through amelioration of the perception of competitive disadvantage. We hypothesized that (1) victims of both systemic inequality and competitive disadvantage would engage in significantly higher risk-taking compared to beneficiaries of inequality, and (2) ameliorating the experience of inequality would result in subsequent reductions in risk-taking behavior.

Experiment 1: Systemic Inequality

Systemic inequality describes inequality imposed by external sources that are beyond an individual's control. Discrimination based on race is an example of systemic inequality. Systemic inequality is particularly affecting in that little personal control can be exerted to avoid victimization. Systemic inequality creates need, in that it creates situations in which people perceive themselves to be at distance between a current state (i.e., a victimized state, with associated costs), and a desired state (i.e., a non-victimized state with associated benefits). Consequently, systemic inequality should facilitate elevated risk-taking consistent with risk-sensitivity theory, because risk-taking might be the only option leading to benefits not otherwise available to those who are victimized. In this experiment, we imposed conditions of systemic inequality on pairs of participants. We predicted that compared to beneficiaries of systemic inequality, victims of systemic inequality would engage in higher risk-taking.

Method

Ninety participants (46 women, 44 men, age: M = 20.1, SD = 2.6, *Range* = 18-34) were run in same-sex pairs. The experiment was advertised as a personality study offering bonus marks. After arriving at the laboratory, participants were seated in close proximity on a couch. Participants were randomly assigned to either the experimental condition (14 pairs), or one of two control conditions: a no-payment control condition (14 pairs), or a $10-payment control condition (12 pairs).

In the experimental condition, one participant was given $10, and the other, nothing, following a brief introduction of the study. Before each experimental session, the experimenter flipped a coin to determine whether the first or second participant to arrive received $10. Participants were told that this payment inequality was due to funding restrictions dictating that only half of the participants could be paid, and that the recipient was chosen at random with a coin flip prior to the experimental session.

In the no-payment control condition, both participants received nothing. In the $10-payment control condition, both participants were given $10 and told that payment was offered due to an excess of funding. Following payments, each participant was directed to a private testing room, where they completed the dependent measure of risk-propensity and measures of individual differences relevant to risk-propensity and sensitivity to justice on a computer, as follows.

Choice Task (CT). Participants made six decisions, each between two monetary options (Mishra & Lalumière, 2010a; adapted from Fessler, Pillsworth, & Flamson, 2004). Both options had equal 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 virtual die on the computer 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. The CT has been previously associated with state-dependent changes in mood (Fessler et al., 2004).

Brief Sensation Seeking Scale (BSSS). The BSSS is a brief measure of sensation-seeking (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). It consists of 10 items associated with sensation-seeking behavior in various domains (e.g., "I prefer friends who are excitingly unpredictable"). Items were rated on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). This measure has shown high reliability and validity and is associated with real-world risk-taking (Hoyle et al., 2002).

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. The EIS has been associated with a variety of risky behaviors in various domains (reviewed in Zuckerman, 2007).

Justice Sensitivity Scale (JSS). The JSS (Schmitt, Gollwitzer, Maes, & Arbach, 2005) measures sensitivity to justice issues and fairness (e.g., "It bothers me when others receive something that ought to be mine"). Items were rated on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Personal Relative Deprivation Scale (PRDS). The PRDS (Callan et al., 2008) measures the degree to which people feel deprived relative to others (e.g., "I feel resentful when I see how prosperous other people seem to be"). Items were rated on a scale from -3 (*strongly disagree*) to +3 (*strongly agree*). The PRDS has been associated with gambling tendencies (Callan et al., 2008).

The CT was always presented first, followed by the individual differences measures in randomized order. At the conclusion of the experimental session, participants received the amount of their earnings in cash from one of their choices on the CT. All participants received bonus course marks and $10 (if they had not already received it) to reduce any remaining effects of inequality. All participants were thoroughly debriefed following this and all other experiments.

Results and Discussion

All data were normally distributed except for the PRDS, which was normalized using a logarithmic transformation. No missing values were observed, and no outliers were detected. A sex (male, female) × inequality condition (inequality victim, inequality beneficiary, no-payment control, $10-payment control) between-subjects analysis of covariance (ANCOVA) was conducted on number of risky choices in the CT. Covariates were the individual differences measures (BSSS, EIS, PRDS, JSS).

A main effect of inequality on risky choice was observed, $F(3, 78) = 3.19, p = .03, \eta^2 = .10$. Inequality victims exhibited significantly higher risky choice compared to beneficiaries of inequality and participants in the control conditions, $M_{victim} = 3.16$, $M_{beneficiary} = 1.89$, $M_{no\text{-}payment} = 2.07$, $M_{\$10\text{-}payment} = 1.96$, all ts > 2.45, ps < .02 (Figure 6.1). Risky choice did not differ between the two control conditions, $t(50) = -0.31, p = .76$, or between beneficiaries of inequality and those in the two control conditions (both ts < 0.42, ps < .68). There was no significant main effect of sex, $F(1, 78) = 0.27, p = .61, \eta^2 = .01$, and no significant sex by inequality condition interaction, $F(3, 78) = 0.53, p = .66, \eta^2 = .02$. None of the covariates were significant, all Fs < 1.54, ps > .22.

Victims of inequality engaged in significantly more risky choice compared to both beneficiaries of inequality and those in no-payment and $10-payment control conditions. That participants did not exhibit significantly different patterns of risky choice based on payment amount indicates that differential risk-acceptance is due to inequality and not payment amount. These results also indicate that being the victim of inequality leads to elevated risk-taking, rather than being the beneficiary of inequality leading to suppressed risk-taking. Together, the results of Experiment 1 demonstrate that being the victim of systemic inequality leads to higher risk-taking.

Experiment 2: Competitive Disadvantage

Experiment 1 demonstrated that systemic inequality facilitates increased risk-taking. Another form that inequality can take is competitive disadvantage. Competitive disadvantage describes inequality derived from the perception that one is not (or will not be) successful in competition with others. People who perceive themselves to be at competitive disadvantage relative to others may possess low embodied capital, which refers to intrinsic attributes such as intelligence, health, or attractiveness that allow for successful competition with others. In Experiment 2, we examined whether the perception of competitive disadvantage facilitated increased risk-taking. We hypothesized that individuals induced to perceive themselves to be at competitive disadvantage relative to others would engage in higher risk-taking compared to those induced to perceive themselves at competitive advantage relative to others.

Method

Fifty-nine participants (28 women, 31 men; age: *M* = 20.8, *SD* = 2.4, *Range* = 18-29) were run individually at computers. The experiment was advertised as a personality study offering bonus marks. Participants were randomly assigned to a control (*n* = 18), competitive advantage (*n* = 21), or competitive disadvantage condition (*n* = 20).

All participants completed a purported intelligence test. This task comprised a blank screen with a black square that would appear in a random location. Participants were told that their goal was to click on the square as quickly as possible, which resulted in the start of another trial and the square moving to another randomly determined location on the screen. Participants went through 30 trials of this task. The task description provided false information indicating that speed of response was highly correlated with intelligence, and that performance on this test was correlated with such life outcomes as income and happiness.

Participants received feedback after completing the purported intelligence test both in the form of a written description of the results and a diagram consisting of a bar summarizing the full range of purported scores from 0 to 100. On this bar, the participants' score was shown, as was the purported average of 46/100. In the competitive advantage condition, participants were told they obtained an above-average score of 71/100. In the competitive disadvantage condition, participants were told they obtained a below-average score of 21/100. In the control condition, participants did not receive any feedback on their performance.

After the competitive advantage/disadvantage manipulation, participants completed the same dependent measure of risky choice (CT) and individual differences measures described in Experiment 1. As in Experiment 1, the CT was always presented right after the inequality manipulation, followed by the individual differences measures in randomized order. All participants received their earnings from one of their choices on the CT at the end of the study.

Results and Discussion

All data were normally distributed. There were no missing values, and no outliers were detected. A sex (male, female) × inequality condition (control, competitive advantage, competitive disadvantage) between-subjects ANCOVA was conducted on number of risky choices made in the CT. Covariates were the individual differences measures (BSSS, EIS, PRDS, JSS).

A main effect of inequality condition on risky choices made in the CT was observed,

$F(2, 49) = 6.07$, $p = .004$, $\eta^2 = .20$. Participants in the competitive disadvantage condition engaged in significantly higher risky choice than did participants in the competitive advantage condition, $t(39) = 4.51$, $p < .001$, and participants in the control condition, $t(36) = 2.26$, $p = .03$, $M_{disadvantage} = 3.45$, $M_{advantage} = 1.71$, $M_{control} = 2.33$ (Figure 6.2). No significant differences in risky choice were observed between the competitive advantage condition and the control condition, $t(37) = -1.51$, $p = .14$. No main effect of sex was observed, $F(1, 49) = 0.99$, $p = .33$, $\eta^2 = .02$. The sex by inequality condition interaction was also not significant, $F(2, 49) = 0.82$, $p = .45$, $\eta^2 = .02$. None of the covariates were significant, all Fs < 3.26, ps > .08.

Those perceiving themselves to be at competitive disadvantage engaged in significantly higher risk-taking compared to those perceiving themselves to be at competitive advantage and those in the control condition. As in Experiment 1, being the perceived victim of inequality—in this case, manifesting through competitive disadvantage—is associated with significantly higher risk-acceptance. That inequality in a non-monetary domain facilitated increased risky choice on a monetary task suggests that the effect of inequality on risk-taking is domain-general. Specifically, inequality may facilitate greater preference for high variance outcomes independent of the domain in which inequality was experienced. Substantial evidence suggests that various forms of risky behavior (e.g., crime, gambling, substance use, dangerous driving, sexual risk-taking) tend to co-occur among individuals, supporting the hypothesis that risk is domain-general (reviewed in Mishra & Lalumière, 2010b). The results of Experiments 1 and 2 indicate that inequality manifesting through both systemic means and competitive disadvantage facilitate risk-taking.

Experiment 3: Removing Systemic Inequality

Experiments 1 and 2 demonstrated that both systemic inequality and competitive disadvantage lead to elevated risk-taking. If risk-taking comprises a response to situations of high need, then decision-makers should be acutely sensitive to changes in the perception of need. Risk-taking carries high potential costs, and decision-makers should avoid such costs when possible. In Experiment 3, we examined whether eliminating conditions of systemic inequality would lead to reductions in risk-taking behavior. We hypothesized that (1) being the victim of systemic inequality would induce elevated risk-taking, replicating the results of Experiment 1, and (2) victims of systemic inequality who experienced amelioration of such inequality would engage in subsequently lower risk-taking.

Method

Ninety-six participants (48 women, 48 men, age: M = 20.3, SD = 2.3, *Range* = 18-28) were run in same-sex pairs. The experiment was advertised as a two-part personality study offering bonus marks. After arriving at the laboratory, participants were seated in close proximity on a couch. Participants were randomly assigned to either an inequality-control condition (24 pairs), or an inequality-reduction condition (24 pairs).

In the inequality-control condition, systemic inequality was induced as in Experiment 1 (using random asymmetrical $10/$0 payments). Following payment, each participant was directed to a computer in a private testing room, where they completed the dependent measure of risk-propensity (CT), and two of the four individual differences measures described in Experiment 1. After completing these measures, participants emerged from their testing rooms and were re-seated in close proximity on the couch. The experimenter then told the participants they would now participate in the second part of the study involving a different research question. After this second introduction, participants were directed into separate testing rooms where they completed a second administration of the CT, followed by the two remaining individual differences measures. Individual differences measures were presented in random order.

The inequality-reduction condition was identical to the inequality-control condition, with one difference. Before the introduction to the second part of the study, participants were given asymmetrical $10/$0 payments as at the beginning of the study, except the recipient of the $10 was reversed. Participants were told that the second part of the study had funding restrictions analogous to the first part of the experiment, but in order to try and make things as fair as possible, the two separate studies were run together, and payments were reversed so that every participant received the same compensation in the end. Following the second set of payments, participants were directed into separate testing rooms where they completed a second administration of the CT and the two remaining individual differences measures. Participants received the amount of their earnings from one of their choices in each of the two CT administrations.

Results and Discussion

All data were normally distributed. There were no missing values, and no outliers were detected. A sex (male, female) × inequality condition (victim/inequality-control, beneficiary/inequality-control, victim/inequality-reduction, beneficiary/inequality-reduction) × CT administration (first, second) mixed ANCOVA was conducted on number of risky choices made in the CT. Covariates were the individual differences measures (BSSS, EIS, PRDS, JSS).

As predicted, a significant interaction between CT administration and inequality condition was observed, $F(3, 84) = 4.26$, $p = .007$, $\eta^2 = .05$. No significant main effect of CT administration was observed, and none of the covariates or any of the other interactions were significant in any analyses (all Fs < 2.68, ps < .11).

Among participants who were the initial victims of inequality, dependent t-tests indicated that in the inequality-reduction condition, victims who experienced amelioration of inequality exhibited significantly lower risky choice in the second administration of the CT, $t(23) = 3.23$, $p = .001$, $M_{victim} = 3.00$, $M_{beneficiary} = 1.71$. In the inequality-control condition, victims who did not experience amelioration of inequality did not exhibit any significant change in risky choice among the two administrations of the CT, $t(23) = 0.75$, $p = .46$, $M_{victim} = 2.88$, $M_{control} = 2.67$.

Amelioration of inequality among initial victims of inequality had no effect on risky choice among those who were the initial beneficiaries of inequality. Among participants who were the initial beneficiaries of inequality, dependent t-tests indicated no difference in risky choice among the two administrations of the CT in the inequality-reduction condition, $t(23) = 0.00$, $p > .99$, $M_{beneficiary} = 1.92$, $M_{beneficiary} = 1.92$, or in the inequality-control condition, $t(23) = -1.66$, $p = .11$, $M_{beneficiary} = 2.17$, $M_{control} = 2.63$ (Figure 6.3).

Across all conditions, participants who were the initial victims of inequality exhibited significantly higher risky choice than did initial beneficiaries of inequality in the first administration of the CT, $t(94) = -3.22$, $p = .002$, $M_{beneficiary} = 2.04$, $M_{victim} = 2.94$. These findings replicate those of Experiment 1.

The results of Experiment 3 suggest that ameliorating systemic inequality can cancel the effects of systemic inequality on risk-taking. Those who were initial victims of inequality, but had this inequality removed, showed significant decreases in risk-taking following inequality removal. However, victims of initial inequality did not show reduced risky choice in the inequality-control condition where inequality was not subsequently ameliorated. These results indicate that reductions in risky choice were due to elimination of inequality, and not due to any temporal or repeated testing effects. That the effects of inequality on risky choice were eliminated on a short temporal scale suggests that effects of inequality on risk-taking may be easily remedied through changes in the sources of systemic inequality. Together, the results suggest that systemic inequality has a causal effect on risky choice.

Experiment 4: Removing Competitive Disadvantage

The results of Experiment 3 suggest that risky choice is sensitive to both the introduction and subsequent removal of systemic inequality. Experiment 4 examined whether risky choice is similarly sensitive to the presence and absence of the perception of competitive disadvantage. Specifically, we examined whether (1) amelioration of the perception of competitive disadvantage leads to lower risk-taking, (2) repeated feedback indicating competitive disadvantage leads to elevated risk-taking, and (3) inconsistent feedback leads to reduced risk-taking. We hypothesized that participants would increase risk-taking when under the perception that they are at competitive disadvantage relative to others, but would engage in decreased risk-taking if this perception was eliminated.

Method

One-hundred participants (48 women, 52 men, age: M = 21.0, SD = 2.3 *Range* = 18-28) were run at individual computer stations. The experiment was advertised as a personality study offering bonus marks. Each experimental condition had the following structure. First, participants were induced into perceiving themselves to either be at competitive disadvantage or competitive advantage relative to peers using a purported intelligence test (as in

Experiment 2). Following this inequality manipulation, participants completed the CT, then two individual differences measures.

After the CT and the first individual differences measures were completed, participants were again induced into perceiving themselves to either be at competitive disadvantage or competitive advantage relative to others. Participants then completed the CT for a second time, then the remaining individual differences measures. Participants were told before completing the second purported intelligence test that the test was prone to error, and only through repeated administration of the test could an accurate measure of intelligence be acquired. They were also told that the second test provided more accurate results because of this effect. The individual differences measures used in Experiment 4 were identical to those used in the previous experiments and were presented randomly.

Participants were randomly assigned to one of four conditions: disadvantage-control, disadvantage-advantage, disadvantage-disadvantage, and advantage-disadvantage ($n = 25$ for all conditions). In the disadvantage-control condition, participants were initially induced into perceiving themselves to be at competitive disadvantage. A second inequality manipulation was not used. Rather, participants completed the same task purported to measure intelligence, but were not given any feedback. The disadvantage-control condition allowed for the examination of whether effects of perceived competitive disadvantage faded with time.

In the disadvantage-advantage condition, participants were first induced to perceive themselves to be at competitive disadvantage, then to perceive themselves to be at competitive advantage (i.e., participants were given disconfirmatory evidence opposing initial feedback indicating competitive disadvantage). In the disadvantage-disadvantage condition, participants were induced to perceive themselves to be at competitive disadvantage twice (i.e., given confirmatory evidence supporting initial feedback indicating competitive disadvantage). In the advantage-disadvantage condition, participants were induced to perceive themselves at competitive advantage, then to perceive themselves to be at competitive disadvantage (i.e., given disconfirmatory evidence against initial feedback indicating competitive advantage). All participants were carefully debriefed following the study. Participants received the amount of their earnings from one of their choices the CT.

Results and Discussion

There were no missing values, and no outliers were detected. A sex (male, female) × inequality condition (disadvantage-control, disadvantage-advantage, disadvantage-disadvantage, advantage-disadvantage) × CT administration (first, second) mixed ANCOVA was conducted on risky choices made in the CT. Covariates were the individual differences measures (BSSS, EIS, PRDS, JSS).

As predicted, a significant interaction between CT administration and inequality condition was observed, $F(3, 88) = 6.34$, $p = .001$, $\eta^2 = .07$ (Figure 6.4). Participants in the disadvantage-control condition did not exhibit a significant difference in risky choice among the two administrations of the CT, dependent $t(24) = -0.27$, $p = .79$, $M_{\text{disadvantage}} = 2.68$, $M_{\text{control}} = 2.72$. These results suggest that the effects of perceived competitive disadvantage on risky choice do not fade with the simple passage of time.

Participants in the disadvantage-advantage condition exhibited significantly less risky choice following presentation of feedback indicating they were competitively advantaged, dependent $t(24) = 4.34$, $p < .001$, $M_{\text{disadvantage}} = 2.96$, $M_{\text{advantage}} = 2.08$. This result suggests that ameliorating the perception of competitive disadvantage can eliminate effects of perceived competitive disadvantage on risk-taking.

Participants in the disadvantage-disadvantage condition exhibited marginally higher risk-taking after receiving feedback confirming they were competitively disadvantaged, $t(24) = -1.78$, $p = .09$, $M_{disadvantage} = 2.64$, $M_{disadvantage} = 3.28$. This result suggests that confirmation of competitive disadvantage may lead to further increases in risk-taking, although this result must be interpreted with caution because it was not statistically significant.

Participants in the advantage-disadvantage condition did not exhibit a significant difference in risky choice across the two administrations of the CT, dependent $t(24) = -1.51$, $p = .14$, $M_{advantage} = 2.00$, $M_{disadvantage} = 2.40$, suggesting participants may have discounted later feedback of competitive disadvantage after already having received feedback indicating they were competitively advantaged (although results were in the expected direction).

No other significant main effects or interactions were observed within or between-subjects (all Fs < 1.62, ps > .21). That a between-subjects main effect of condition was not observed for risky choice on the first administration of the CT is puzzling; this effect would have replicated the findings of Experiment 2. An omnibus ANCOVA model may have masked between-subjects effects of competitive disadvantage due to reduced statistical power, so an independent t-test was used to examine whether risky choice varied between-subjects as a function of initial competitive advantage or disadvantage. Those who perceived themselves to be competitively disadvantaged prior to the first administration of the CT engaged in significantly higher risky choice compared to those who perceived themselves to be competitively advantaged, $t(98) = 2.24$, $p = .03$, $M_{disadvantage} = 2.76$, $M_{advantage} = 2.00$. This result replicates the findings of Experiment 2. Together, the results of Experiment 4 suggest that inequality manifesting through competitive disadvantage has a causal influence on risk-taking.

General Discussion

The results of four experiments indicated that people make decisions conforming to the predictions of risk-sensitivity theory under conditions of inequality. People who were induced to be the victims of both systemic inequality and competitive disadvantage engaged in significantly higher risk-taking than participants induced to be the beneficiaries of inequality and participants in control conditions. Furthermore, the effect of inequality on risk-taking was demonstrably plastic. Eliminating the initial perception or experience of systemic inequality or competitive disadvantage led to subsequent reductions in risk-taking behavior. These results were obtained controlling for individual differences in risk-propensity and sensitivity to justice outcomes. Together, the results strongly indicate that the experience of inequality causes risk-taking.

The samples used in the four experiments in this study comprised undergraduate university students. Competitive disadvantage was manipulated in a domain hypothesized to be important to university students, and as such, participants may have been disproportionately sensitive to feedback indicating they scored below average in intelligence (Experiments 2, 4). Replication of these findings is necessary among more diverse populations to demonstrate their generality. Other domains of competitive disadvantage may be more salient to other populations.

The transparency of the manipulations used in this study may have been problematic. Many undergraduate psychology students participate in experimental studies expecting to be deceived or given false feedback. Participants may have thus discounted the inequality manipulations. Following debriefing at the end of the study, some participants indicated that they had indeed suspected that the systemic inequality manipulation ($10/$0) was a deliberate manipulation. Similarly, some participants indicated that they discounted feedback indicating low intelligence. However, some participants were legitimately concerned that the experimenter would be treating students so unfairly regarding asymmetrical payments, and some exhibited visible signs of being upset following competitive disadvantage manipulations (before debriefings).

That the manipulations affected risky behavior even with some participants being suspicious suggests that the experience of inequality is particularly salient. In everyday situations, victims of systemic inequality and competitive disadvantage would experience persistent feedback emphasizing such inequalities (e.g., racial discrimination), potentially leading to even greater elevation of risky behavior. That inequality has been so robustly associated with various forms of risky behavior at the aggregate level (reviewed in Wilkinson & Pickett, 2009) supports this hypothesis.

Inequality of different forms—systemic inequality and competitive disadvantage—appears to play a causal role in motivating risk-taking. The experience of inequality motivated elevated risky choice, and removal of the experience of inequality resulted in decreased risky choice. The effect of inequality on risky choice manifested in short timeframes, suggesting that inequality is a salient motivator of risky behavior to which people are acutely sensitive. These results have important implications in devising social policy that leads to reductions in rates of such societally harmful risky behaviors as crime and excessive gambling. Aiming to affect modifiable environmental causes of risk-taking, such as inequality manifesting through unequal access to health care, education, and other opportunities, may lead to significant reductions in risky behavior.

Figure 6.1.

Number of risky choices on the CT (M±SE) as a function of systemic inequality condition.

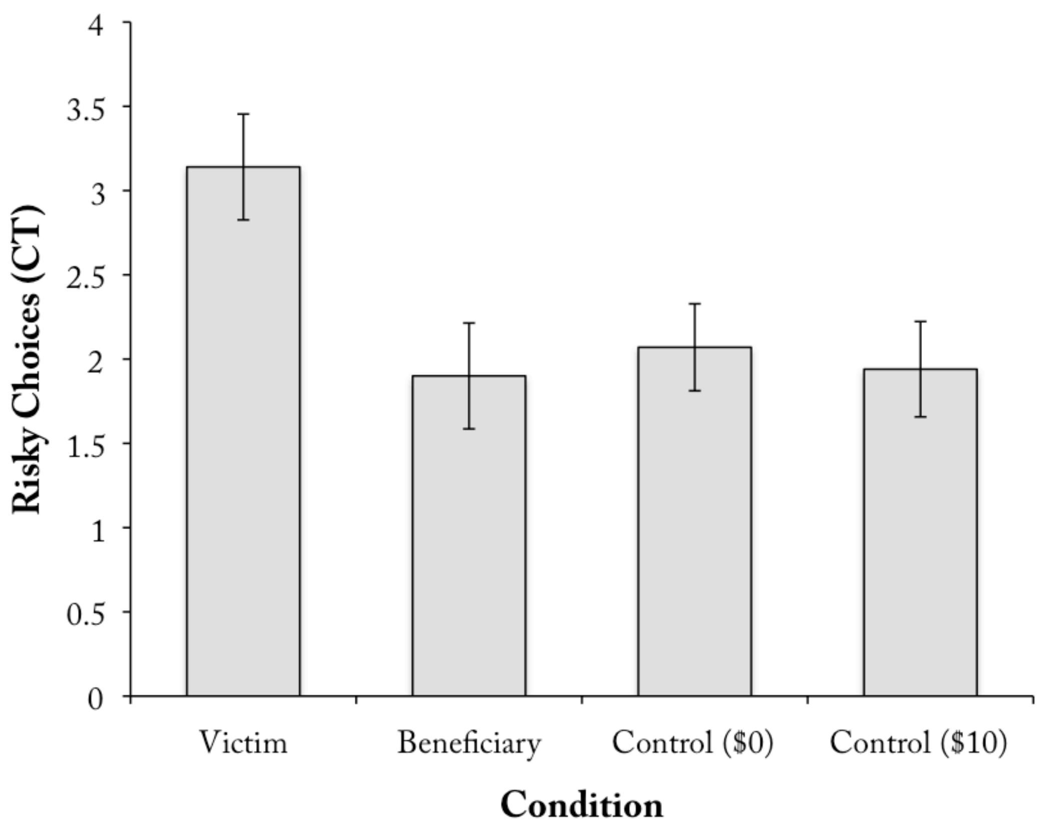


Figure 6.2.

Number of risky choices on the CT (M±SE) as a function of competitive disadvantage condition.

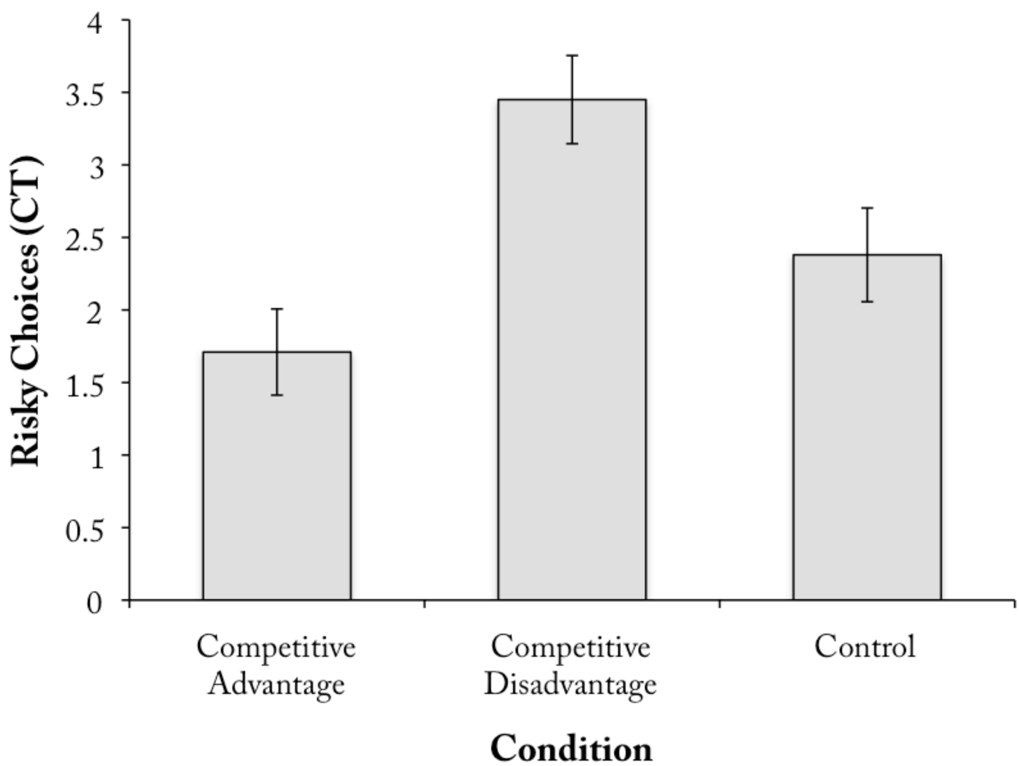


Figure 6.3.

Number of risky choices on the CT (M±SE) among inequality victim-beneficiary pairs in the inequality-control and inequality-reduction conditions. Risky choices made in the first and second administrations of the CT are represented by light and dark grey bars, respectively.

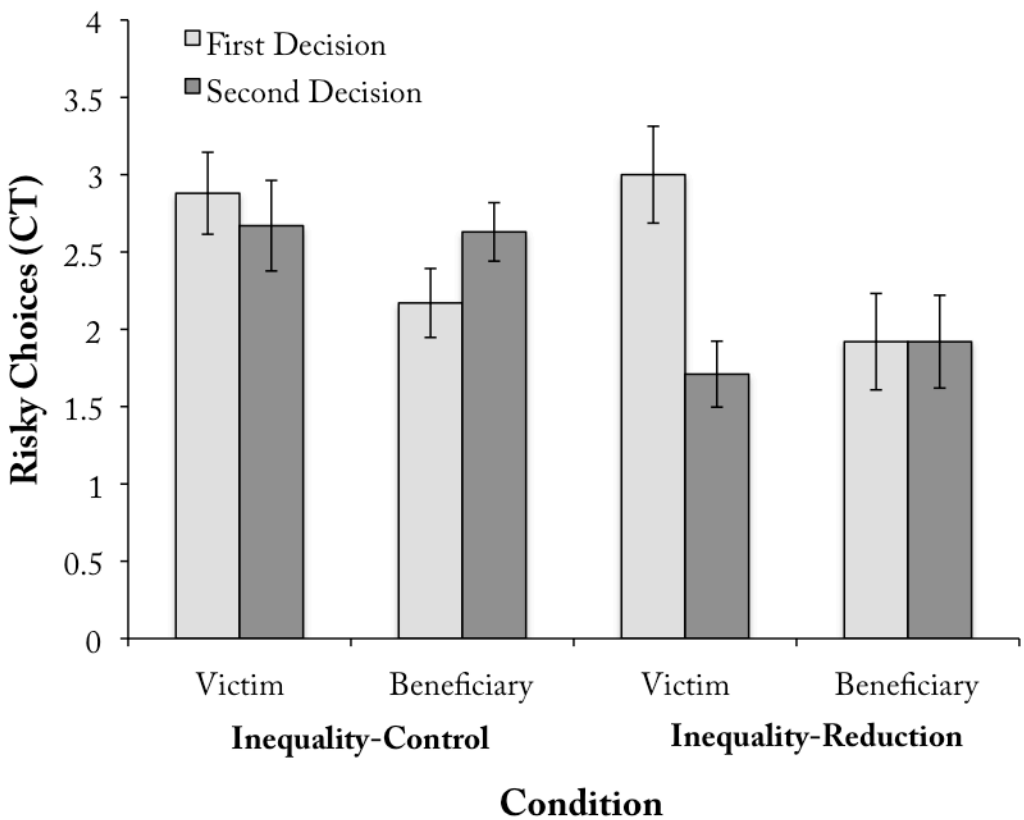
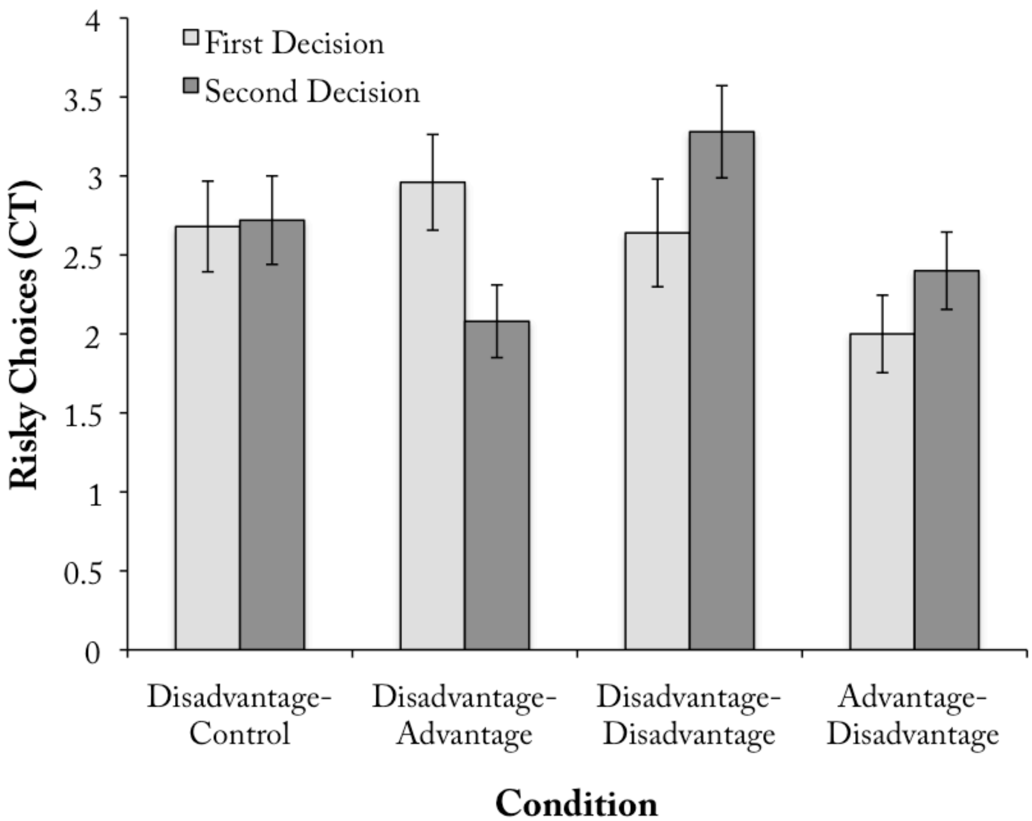


Figure 6.4.

Number of risky choices on the CT (M±SE) among individuals in the four competitive disadvantage–advantage conditions. Risky choices made in the first and second administrations of the CT are represented by light and dark grey bars, respectively.



CHAPTER SEVEN

Summary and Implications

General Summary

The research presented in this dissertation examined how various situational cues facilitate risky behavior. Risky behavior is typically considered irrational, pathological, or maladaptive. From an evolutionary perspective, however, risk-taking may be adaptive under certain circumstances: Risk-sensitivity theory predicts that decision-makers shift from risk-aversion to risk-preference in situations of high need, where need describes disparity between an individual's present state and desired state (Stephens, 1981). Someone with a $2,000 debt, for example, might shift from a risk-averse preference of earning a certain $200 to a risk-prone preference of a 10% chance of winning $2,000, because the latter option is the only one that even allows a chance of meeting their need.

Most normative theories of decision-making under risk posit that decision-makers seek to maximize the currency of utility, which is broadly defined as happiness, gratification, or satisfaction derived from a behavior (Friedman & Savage, 1952; Kahneman & Tversky, 1979). A broadly relevant theory of decision-making must acknowledge, however, that the pursuit of proxies of fitness motivates decision-making (Daly & Wilson, 2001). Seeking fitness is an abstract goal; decision-makers likely do not actively consider the degree to which any particular decision affects their lifetime reproductive fitness. However, resources correlated with fitness in ancestral environments—material resources, social status, and mating opportunities—are tangible currencies that decision-makers can seek to maximize in individual decisions. Only risk-sensitivity theory offers an explanation for why decision-makers might privilege evolutionarily salient needs in decision-making.

In Chapter Two, I critically reviewed and integrated the most influential theories of decision-making derived from the behavioral sciences. Of these theories, risk-sensitivity theory is the only one that (1) accounts for fitness-related motivations, (2) provides a normative rationale explaining choice in myriad domains (i.e., the motivational effect of need), and (3) can account for various empirical findings (e.g., the generality of risk, the role of the environment, and individual differences, among others). Chapter Two described how a general theory of decision-making based largely on risk-sensitivity theory is consilient with other widely utilized theories of decision-making, and can account for broad patterns of decision-making behavior.

Substantial evidence suggests that risk-taking is a general phenomenon, inclusive of diverse behaviors all involving variance in outcome (e.g., crime, gambling; reviewed in Mishra & Lalumière, 2009; Mishra & Lalumière, 2010b; Mishra, Lalumière, Morgan, & Williams, 2010). The study reported in Chapter Three examined the relationship between self-report measures of personality traits associated with risk and behavioral measures of risk-taking. Although such personality traits as sensation-seeking, low self-control, and impulsivity have been associated with real-world risky behaviors (reviewed in Zuckerman, 2007), little evidence has shown that these traits are associated with a behavioral preference for risk in laboratory tasks. The results from the study presented in Chapter Three showed that personality traits associated with risk and behavioral measures of risk were significantly correlated, suggesting that personality traits may in part be proximate mechanisms through which behavioral preferences for risky outcomes manifest, even in the laboratory.

The study reported in Chapter Four examined whether gambling is a form of risk-taking. Indicators of risk-propensity, including self-reported personality traits, laboratory-based behavioral measures of risk, and self-reported attitudes toward risk in various domains were all significantly associated with general gambling involvement and problem gambling behavior in a sample of university students, using an extreme-groups design. Furthermore, the variance underlying measures of gambling and risk-taking was adequately accounted for by a single principle component, suggesting that gambling represents one expression of a general propensity for risk-taking.

In Chapter Two, I argued that the most effective theoretical approach for examining decision-making under risk should be primarily modeled on risk-sensitivity theory. Although growing evidence suggests that people make risky decisions in a manner consistent with risk-sensitivity theory, little research has examined whether people make risk-sensitive decisions in more ecologically relevant decision-making scenarios. The study presented in Chapter Five indicated that people preferred high-risk options when they were induced into situations of high need, where low-risk options were unlikely to meet their need. These results were obtained both when people were explicitly aware of the parameters of decision options (i.e., probabilities), and when they implicitly learned the parameters of decision options through experience (i.e., a more ecologically relevant method of decision-making). Recent research has replicated and extended these findings, providing further evidence that risk-sensitivity theory can effectively explain patterns of decision-making in humans (Mishra & Fiddick, 2010; Mishra, Gregson, & Lalumière, 2010).

A particularly salient form of need that manifests in diverse domains is inequality. The experience, or even the perception, of inequality represents a condition of high need: If someone is a victim of inequality, they are at distance from a desired state (that state being the relative success of others). Inequality has been associated with various risky behaviors at the aggregate level (reviewed in Wilkinson & Pickett, 2009), but little experimental evidence has examined whether participants induced to perceive themselves to be victims of inequality engage in increased risk-taking. Chapter Four described four experiments that examined whether the introduction and elimination of inequality caused respective increases and decreases in risk-taking. Results indicated that the experience of inequality both in the form of systemic inequality and competitive disadvantage facilitated increased risk-acceptance, and elimination of the experience of inequality facilitated reduced risk-acceptance. These results were obtained controlling for individual differences relevant to both risk-propensity and sensitivity to justice, suggesting that these findings are robust.

Implications

Previous research into the causes of risk-taking has been largely domain-specific. My results contribute to a substantial body of evidence indicating that a wide array of risky behaviors—crime, substance use, risky driving, early sexual intercourse, sexual aggression, gambling, general delinquency, and antisocial behavior—seem to be analogous manifestations of a preference for variable outcomes (reviewed in Chapter Three). Future research would benefit from treating risky behavior as a phenomenon to be explained more generally. One implication of this approach is that interventions may potentially have multiple effects on risk-taking across multiple domains.

Most research into the causes of risk-taking has been informed by utility-based theories of decision-making such as expected utility theory or prospect theory. However, risk-sensitivity theory offers novel predictions about the motivations underlying risk-taking. Specifically, need should motivate risk-taking in almost every domain through a simple mechanism—if decision-makers are unable to acquire what they want through low-risk options, they should seek high variance, risky options that at least offer a chance of bridging the gap between their present and desired states. This approach has the added benefit of being compatible with traditional theories of risk-taking, as long as the traditional notion of utility is re-conceptualized as the probability of meeting one's needs (reviewed in Chapter Two). That need manifesting in different forms explained a large proportion of variance in decision-making—up to 77% (Chapter Five)—suggests that need is a powerful motivator of risky behavior. Furthermore, the results presented in Chapter Six indicated that people are acutely sensitive to the introduction and removal of situations of need manifesting in the form of inequality. Together, this evidence strongly suggests that need is an important cause of risk-taking.

Because risk-acceptance is demonstrably influenced by the environment, it is possible to use these results to inform social policy aimed at reducing rates of societally harmful risky behaviors. Most approaches to understanding the etiology of risky behavior are too narrowly focused. However, utilizing an evolutionary approach—where risk-taking is conceived as potentially adaptive under some circumstances—may lead to a more productive understanding of the causes of, and solutions to, such societal issues as crime, gambling, and other harmful risky behaviors. Aiming to affect modifiable environmental causes of risk-taking, such as inequality manifesting through unequal access to health care, education, and other opportunities, may lead to significantly lower rates of various forms of harmful risky behavior.

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