Cognitive Anomalies and the Assumption of Economic Rationality: An Empirical Investigation of UNC Students

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Abstract

Descriptive[1] theories of risky choice are at the center of a current debate in economic theory. Standard neoclassical theory views economic agents as rational individuals with consistent preferences, which facilitates acting in ways that maximize their expected utilities in almost every possible situation. An alternate descriptive theory, first advanced by cognitive psychologists and quickly adopted by behavioral economists, focuses on the psychology of the decision-making process itself, and explores cognitive limitations and inaccuracies that may lead consumers to make sub-rational and therefore sub-optimal choices. The current study replicates a landmark survey originally conducted by Daniel Kahneman and Amos Tversky (KT), from which these cognitive psychologists formulated *prospect theory*. Prospect theory and its extensions represent a formidable challenge to the neoclassical model as the dominant, descriptive theory of consumer choice. This paper reports analyses of surveys of three groups of undergraduate students: economics majors, math and science majors, and "non-science" liberal arts majors. The analysis indicates that economics majors tend to display the relatively highest degree of rationality in their risky-choice preferences, and tend to be more consistent in their personal preferences. Science majors also displayed relatively consistent preferences, but less so than economics majors. The non-science liberal arts majors displayed the least consistency and the highest levels of irrational choices of these groups, and their choices were most consistent with the results obtained in Kahneman and Tversky's original study. The results reported in this paper suggest that the behavior of certain individuals may adhere more closely to traditional economic theories of risky choice, while the

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[1] *Descriptive*, as it is used here and throughout this paper, refers to how we *actually* behave or think, as opposed to how we *should* behave (the *normative*), or ways we might *improve* how we behave (the *prescriptive*).

behavior of other consumers, with less expertise, may more closely accord with alternate theories of risky choice, such as prospect theory.

COGNITIVE ANOMALIES AND THE ASSUMPTION OF ECONOMIC RATIONALITY: AN EMPIRICAL INVESTIGATION OF UNC STUDENTS

Economic theories of consumer behavior are intended to identify the motivations and to describe the behavior of economic agents, and focus on the economic decisions or choices that economic agents face. Scarcity confronts consumers with waves of difficult economic decisions across the course of their lives, and each entails a trade-off between alternatives. Economists strive to understand the choices of agents, or in times of apparent error, what should have been chosen if consumers truly attempt to optimize. In this traditional approach to consumer theory, a central tenet has been the notion of *rationality*, which as described in the Oxford English Dictionary, is "the power of being able to exercise one's reason."

Economic theory has historically pivoted on the assumption of rationality in building normative and descriptive explanations of consumer behavior. The consumer is assumed a rational agent. His possession and use of rationality implies that his actions are expected to accord with achievement of his goals. In the words of Herbert Simon, "The rational man of economics is a maximizer, who will settle for nothing less than the best." The standard theories of competition yield the result that anything but the most rational of choices will quickly be punished, thereby negatively reinforcing an agent's behavior to become consistently rational. Yet, as economic thought has evolved, the notion of "rationality" has been refined and made more specific. It is not necessarily the *definition* of rationality that has changed, but what has changed is the precision of the lens through which the economist views how rationality pertains to consumer behavior.

The standard economic theory that constitutes much of the study of consumer choice is known as *rational choice* (or *consumer choice*) *theory*. The conceptual core of the conventional model consists of an assumption the individuals maximize their self-interest in accord with their individual preferences. This neoclassical theory, posed mathematically, suggests that the rational goal of each individual is to achieve one's personal goals, whatever they may be. Personal preferences are the comparative weights subjectively assigned to alternative bundles. The conventional analysis typically assumes transitivity and completeness, and that our preferences can be expressed mathematically through an ordinally specified scale of *utility*[2]. The degree to which we are able to achieve our goals determines the amount of ordinally measured utility we gain or lose as a consequence of a choice or action (Baron 2000). Rational choice theory postulates that each person's goal, as a rational economic agent, is to maximize the achievement of his or her goals. This theory concludes that our main objective is (positive) and should be (normative) to make the decisions that maximize our expected utility. It is for this reason that *rational choice theory* is synonymous with *expected utility theory* (EUT), and these terms will be used interchangeably throughout this paper[3].

In 1944, Van Neumann and Morgenstern first outlined the mathematical axioms that underpin rational choice theory. These axioms include:

Completeness: For all acts A and B, either A is preferred to B or B is preferred to A or A and B are equally desirable.

Transitivity: If A is preferred to B and B is preferred to C, than A should be preferred to C.

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[2] Sir John Hicks is credited with altering conventional economic thought to the use of an ordinal scale of utility, rather than a cardinal scale.

[3] It should be noted that rational choice theory uses deterministic math while expected utility theory introduces risk and generates stochastic outcomes.

Substitution: If A is preferred to B, then an even chance to get A or C is preferred to an even chance to get B or C.

Dominance: If prospect A is at least as good as prospect B in every respect and better than B in at least one respect, than A should be preferred to B.

Invariance: The preference between A and B should not depend on the order or method in which A and B are described. In particular, two versions of a choice problem should elicit the same preference even when shown separately.

Reflexiveness: Any prospect A is at least as good as itself.

These guidelines provided a prescriptive framework for analyzing risky behavior and also opened the door to a variety of research to test experimentally the validity of consumer choice theories. In so far as these axioms incorporate logic with mathematical terminology, these six principles of rationality provided the basis on which the rational consumer model was originally based. Behavior was considered rational if in accord with these axioms, which were meant to be assumptions that no reasonable or rational person could violate (Anand 1993). Although economists have never believed that human judgment was infallible, errors in judgment were thought to vary unsystematically and without mean errors of zero.

The standard rational choice theory, as many economists have maintained, can be summarized by the simple rule, "The rational choice is that which is expected to best achieve your goals; or, by extension, choose that which best maximizes your expected utility." Much of the debate about the validity of rational choice theory centers on this emphasis on preference maximization. The standard model of rational choice (EUT) assumes a straightforward flow based on perception, preference, and process rationality. McFadden (1999) summarizes these stipulations of rationality:

> The *standard* model in economics is that consumers behave *as if* information is processed to form perceptions and beliefs using strict Bayesian statistical principles (*perception rationality*), preferences are primitive, consistent, and immutable (*preference rationality*), and the cognitive process is simply preference maximization, given market constraints (*process rationality*).

The standard model of rational choice incorporates a consumer's perceptions and tastes to the cognitive task of preference maximization, which then directly leads to a particular choice, schematically diagrammed as (McFadden 1999):

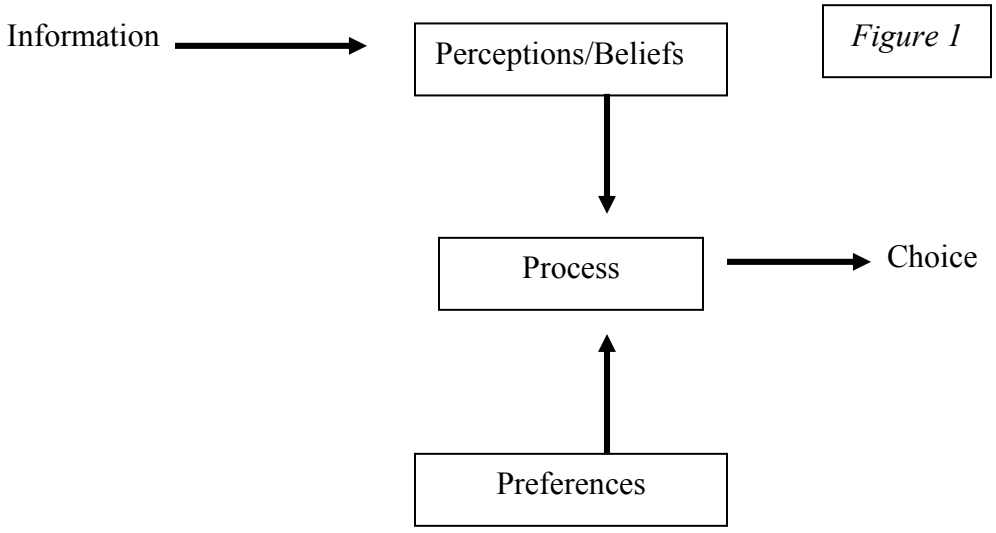


Figure 1

This model emphasizes the mapping of information to the consumer's choice, de-emphasizes the significance of the individual's preferences and perceptions, and treats the actual decision-making process as a sort of black box. There is an absence of concern about the human motivations that actually determine value (Anslie 1982). This standard economic model (expected utility theory) has proven both convenient and largely successful in predicting actual economic behavior. Yet according to growing literature that documents overwhelming behavioral evidence, it is also unnecessarily strong and, in some cases, false (McFadden 1999).

Neoclassical economics subscribes to *expected utility theory* (EUT) to explain how consumers *should* behave when choices involve risk. Furthermore, many

economists also view EUT as an accurate descriptive model of economic behavior (Friedman & Savage 1948). This theory, like other economic theories of consumer choice, is intended to address the conflict between utility and probability in the presence of risk. As it is used in decision theory, the term *risk* implies that the probabilities associated with possible outcomes are assumed known, while the term *uncertainty* is used to denote unknown probabilities.

Expected utility theory, as an outgrowth of rational choice theory, shares the assumption that the consumer's main objective is to choose such that he maximizes his utility. EUT is assumed applicable when an individual must choose between two or more events that have varying levels of utility and varying degrees of occurrence. Since the outcomes of alternative events are uncertain, the individual, unable to predict the future, must choose by combining his assessments of the respective utility and the perceived probability of the available options. The method for making this evaluation, according to EUT, parallels the calculation of the expected value of a monetary gamble. A "gamble," in the language of decision theory, refers to a situation with multiple outcomes and known probabilities of occurrence, but the actual outcome is uncertain. Rather than multiplying the probability of occurrence by its monetary value, EUT dictates that the event's probability of occurrence is multiplied by its utility, as seen by:

$$EU = \Sigma_i \; p_i \; * \; u_i \qquad (1.1)$$

Here, EU represents expected utility, u_i is the utility of the ith outcome, and p_i is the probability of occurrence of the ith outcome. The summation of the products of each possible option's probability and utility is the expected utility of that option. Via statement 1.1, the relationship between expected value and expected utility becomes quite

evident. The application of expected utility theory is based on the following three tenets (Kahneman & Tversky 1979).

(i) Expectation: $U(x_1, p_1;\ldots;x_n, p_n) = p_1\, u(x_1) + \ldots + p_n\, u(x_n)$. (1.2)

This expectation states that the overall utility of a prospect, denoted by U, is equal to the expected utility of its outcomes. (1.3)

(ii) Asset Integration: $(x_1, p_1;\ldots;x_n, p_n)$ is acceptable at asset position w iff

$$U(w + x_1, p_1;\ldots; w + x_n, p_n) > u(w) \quad (1.4)$$

This tenet states that a prospect is acceptable if the integration of that prospect into a consumer's total assets yields a greater expected total utility than those assets alone. This tenet implies that the domain of the utility function is in final states, rather than gains or losses. Additionally, the utility function considers one's asset position, w.

(iii) Risk Aversion: u is strictly concave ($u'' < 0$)

The notion of risk aversion is expressed as the concavity within the utility function. Risk aversion occurs whenever a consumer chooses a certain prospect x over any risky prospect with expected value equal to or greater than x. The notion that utility is a concave function of money is based on the notion of risk aversion and has been a fundamental part of microeconomic analysis since the 18th century from the work of Blaise Pascal. Risk aversion is often ascribed to an assumed diminishing marginal utility of wealth.

However, a number of economists, many in the field of behavioral economics, have speculated on the need for an alternate approach to explain consumer choice and economic rationality. Behavioral economics incorporates psychological notions such as thought processes, environment, social consequences, mood, affect, and experience into

an alternative view of consumer choice theory. While behavioral economics does not dramatically shift the methodologies of economic thought, there is a reorientation in its methodology arising from the belief that "the plausibility of a theory's assumptions should play [a role] in evaluating that theory, and that coherent, rich testable theory *can* be constructed using more realistic assumptions than are typically used" (Camerer 1998). Additionally, it seems in many cases that the addition of psychological variables can complement traditional economic variables to better explain and/or predict economic behavior (Raaij 1981). It should not be surprising that the study of individual consumer choice has led many economists to the notion that economic behavior is a complex function of human motives, perceptions, preferences, affects, attitudes, and expectations.

The behavioral vantage point sees a fundamental flaw in the classical approach to decision theory. Namely, the classical model (EUT) focuses only on choices themselves, and largely ignores the decision-making process per se. In contrast, alternate approaches to the decision-making process, developed primarily from the perspectives of cognitive psychologists, emphasize the decision-making process as the focal point. Additionally, they have reintroduced the idea that behavior is local, adaptive, learned, and dependent on context (McFadden 1999). From this perspective, the standard model of rational choice is being transformed to incorporate an individual's attitudes, affect, and motives, creating a richer, interdependent model:

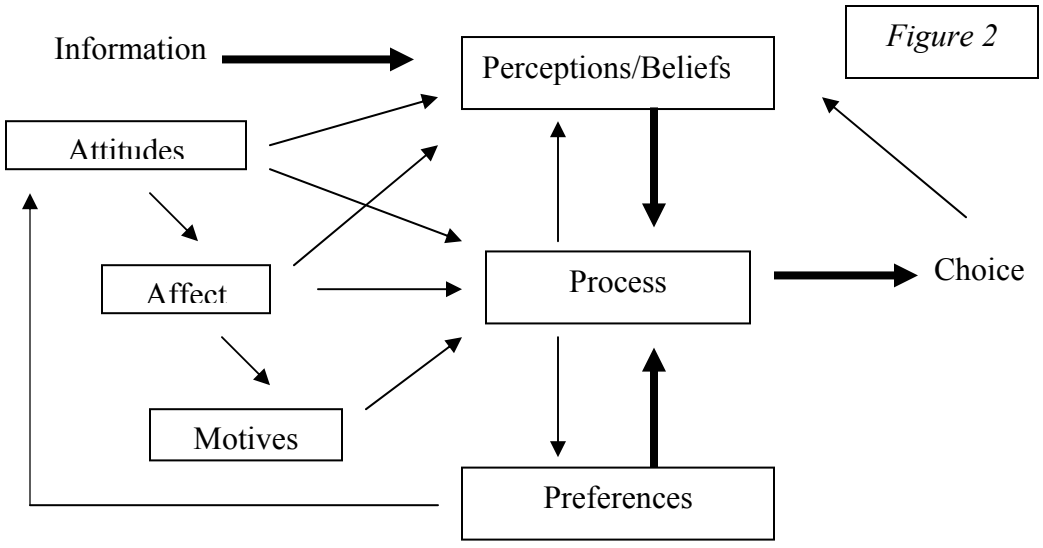


Figure 2

The model in Figure 2 incorporates into the original model of consumer choice (classical model) from Figure 1 (shown with bolder arrows) additional elements drawn from the alternate, behavioral approach. *Figure 2* posits several important deviations from the standard rational choice model. Namely, this model focuses on the *process* of the cognitive task by which a consumer chooses. Beyond this, though, the alternate model depicts the feedbacks and multiple directions of causation between the human elements (i.e. preference, affect, motive) that all affect consumer choice. McFadden eloquently distinguishes the difference between the classical and behavioral approach as, "the behavioral decision maker is driven by many demons, but the economist's decision maker by the one 'devil that made me do it'" (McFadden 1999).

The criticism of the lack of attention to the decision-making process in the standard rational choice model may not be the theory's only weakness. Many researchers have found the mathematical demands of such a model to be, in many instances, beyond the cognitive capacity of most consumers. Rational decision-making requires the consumer to know not only the proper assignments of probability and utility of the events, but she must also be able to perform the mental calculations to choose that which

yields the highest expected utility. In real world situations, the calculation requirements of decisions that have many possible courses of action, each with varying degrees of likelihood, can become quite convoluted. Herbert Simon first noted in 1955 that expected utility theory may be limited due to the cognitive scope of the human mind and coined the term, "bounded rationality" to refer to our inability to process all the information available in a consistent and accurate manner. On the centerpiece of rational choice theory and EUT, Simon writes:

> The assumption of maximization may also place a heavy computational burden on the decision maker. A theory of bounded rationality seeks to identify, in theory and in actual behavior, procedures for choosing that are computationally simpler, and that can account for observed inconsistencies in human choice patterns (1990).

Simon also noted that consumers must have all relevant information to make an accurate choice. Expected utility theory, he notes, requires a great leap of faith by assuming that this is always the case. Furthermore, the inability of most consumers to make complex calculations led Simon to suggest that instead of assuming maximization of a utility function, "we may postulate a satisfying strategy" instead (1990). Cognitive psychologists refer to these "satisficing strategies" as heuristics, or mental shortcuts.

Heuristics are "quick and dirty" methods of problem solving that often suffice to generate approximate estimates or solutions, while allowing the thinker to expend little mental energy. From an adaptive standpoint, using these rules of thumb is often cognitively advantageous. For example, in situations of urgency with limited time to decide, heuristics allow the thinker to generate a solution quickly. From a cost-benefit standpoint, using a heuristic may be advantageous when the alternative method may yield only a marginally better answer at a far greater cost of mental exertion and time. In other words, "there is a point of diminishing returns in the expected utility of thinking itself"

(Baron 2000). Baron notes that for certain decisions, a lengthy and all-encompassing thought process may not be more advantageous than a quick estimation in cases where the particular behavior is relatively simple or inconsequential. As an evolutionary theorist would be quick to note, heuristics clearly play significant roles in our decision-making. Yet there seem to be many situations where using mental shortcuts leads to very erroneous answers which do not vary randomly around means of zero, but instead occur in a systematic and biased fashion.

Since Von Neumann and Morgenstern published the mathematical formulation of expected value theory in 1944, cognitive psychologists and a growing number of economists have devoted substantial parts of their careers to the study of how cognitive anomalies systematically pervade our behavior. The inadequacies of rational choice theory as a perfectly predictive model have led them to focus on alternative explanations of consumer choice under uncertainty and risk. Among the first to respond critically to the Von Neumann and Morgenstern axioms of rational choice was Maurice Allais (1953) who documented the numerous observed deviations from expected utility theory. Allais proposed certain monetary "gambles" by which to demonstrate that the substitution axiom was often violated by decision-makers when choosing between pairs of financial gambles with varying levels of risk and reward. Kahneman and Tversky (1979) presented a version of an Allais' gamble in a subsequent study:

Figure 3

Problem 1: **Problem 2:**

Prospect	Value	Probability		Prospect	Value	Probability
A [18]*	$2,500	0.33		C [83]	$2,500	0.33
	$2,400	0.66			$0	0.67
	$0	0.01		D [17]	$2,400	0.34
B [82]	$2,400	1.00			$0	0.66

*[*x*] denotes the % of respondents (N = 72), which chose the prospect.

This example is noteworthy for several reasons. First, strictly according to the expected value of each prospect, *A* (*e*=$2,409) should be preferred over *B* (*e*=$2,400) and *C* (*e*=$825) should be preferred over *D* (*e*=$816). Immediately, it is clear that the KT (1979) respondents chose differently—a significant majority (82%) chose *B* in Problem 1 and *C* in Problem 2. According to the preferences expressed in Problem 1, it can be understood that

$$u(2{,}400) > .33u(2{,}500) + .66u(2{,}400) \quad \text{or} \quad \mathbf{.34}\boldsymbol{u}\mathbf{(2{,}400) > .33}\boldsymbol{u}\mathbf{(2{,}500)}$$

This preference does not, in isolation, necessarily reflect an irrational choice. If the goal of the chooser is to select the prospect with the highest probability of occurrence (i.e., the "safest bet") then *B* is the rational choice, and it seems that 82% of the subjects responded in accord with this goal. Yet, according to expected utility theory, the preference in Problem 2 (where 83% chose *C* over *D*) implies

$$\mathbf{.33}\boldsymbol{u}\mathbf{(2{,}500) > .34}\boldsymbol{u}\mathbf{(2{,}400)}$$

This reversal of preferences when Problems 1 and 2 are considered jointly (61% chose the modal response in both problems) seems to indicate an inconsistency in preferences that does violate the substitution axiom of rational choice. Recall that the substitution

axiom states that if *A* is preferred to *B*, then an even chance to get *A* or *C* is preferred to an even chance to get *B* or *C*. In other words, if there is some state *C* that leads to the same outcome no matter what choice you make (*A* or *B*), then your choice should not depend on that outcome. This point becomes clearer when the same prospects from the previous example are determined by a lottery.

Figure 4

		Ball numbers		
		1 (*a*)	2-66 (*b*)	67-100 (*c*)
1.	A	$0	$2,500	$2,400
	B	$2,400	$2,400	$2,400
2.	C	$0	$2,500	$0
	D	$2,400	$2,400	$0

State *a* corresponds to ball 1 being selected, state *b* corresponds to balls 2-66 being selected, and state *c* corresponds to balls 67-100 being selected. In that state *c* is identical in both Problems 1 and 2, we should ignore state *c* when deciding between the alternate prospects. State *c* in both of these problems *should be* considered irrelevant when deciding between these two sets of prospects. When the shared states *c* (boxed above) are ignored, the two prospects are shown to be identical. Therefore choosing prospect *A* in Problem 1 rationally corresponds to choosing prospect *C* in Problem 2, and choosing prospect *B* in Problem 1 rationally corresponds to choosing prospect *D* in Problem 2. That this preference pattern did not occur led Kahneman and Tversky to believe that respondents failed to ignore the irrelevant states of occurrence when making their decision, an irrationality they attribute to a cognitive anomaly they termed the *certainty effect*. This phenomenon expresses the consumer's tendency to overweight prospects that are certain to occur over a prospect that is risky, even if the risky prospect has a greater expected value. These prospects demonstrated systematic occurrences (later labeled the

Allais paradox) and sparked a new direction of thought in the debate over consumer choice theory and violations of rationality.

Allais' findings (1953) and Simon's concept of "bounded rationality," first described in 1955, led to extensive research by Amos Tversky and Daniel Kahneman that has focused on the study of how the consumer's cognitive capabilities (or perhaps, inabilities) lead him to make choices that seem incongruent with the harmonious beliefs of rational choice theory. Standard consumer theory (EUT) does in many situations prove an accurate predictor of real-world behavior. However, reliance on expected utility theory to predict consumer behavior in all situations appears ill-advised, given the mounting behavioral evidence that consumer behavior frequently deviates from the rationality assumed in traditional rational choice theory. This does not imply that economists should abandon the notion that economic agents are often intelligent and purposeful in their decision-making. Rather, it merely highlights areas in which consumers fall short of *perfect* rationality.

Kahneman and Tversky initially focused their attention to studies of the decision-making process. They pioneered a number of methods to study this process, which include decision delay times, and subject reports before, during, and after decisions are made (McFadden 1999). Their work uncovered numerous cognitive anomalies, which suggests that observed departures from rationality may sometimes be the norm rather than the exception. Tversky's commentary (1977) on his own results summarizes the body of Kahneman and Tversky's research:

> Our research has shown that subjective judgments generally do not obey the basic normative principles of decision theory. Instead, human judgments appear to follow certain principles that sometimes lead to reasonable answers and sometimes to severe and systematic errors. Moreover our research shows (Tversky and Kahneman, 1974; Kahneman and Tversky, 1979a) that the axioms of rational choice are often violated consistently by sophisticated as

> well as naïve respondents, and that the violations are often large and highly persistent.

The bulk of their research, and the multitude of research efforts that followed in their footsteps, has been aimed at devising an alternate descriptive model of consumer choice under uncertainty and risk.

The remainder of this study is as follows. The next section begins by presenting a brief review of Kahneman and Tversky's most important findings about choice among risky prospects. These notions are of an alternate (descriptive) theory of consumer choice under risk that they term "prospect theory." Here, I also describe criticisms of their findings. Section II introduces the purpose and hypothesis of the present study and its methodology. Section III is devoted to briefly presenting the analytical results of my study, particularly in comparison to the findings from which Kahneman and Tversky extracted prospect theory. Section IV discusses implications of my study for this field of research.

I. PROSPECT THEORY

Kahneman and Tversky have identified three general areas where subjects faced with decisions exhibit choices inconsistent with rational choice theory. First, decision-makers have trouble handling information and forming consistent perceptions. Second, decision-makers use heuristics that fail to lead to maximization of their preferences. Finally, Kahneman and Tversky found that decision-makers are overly sensitive to context, which leads to violations of the rational choice axioms.

These findings led to the development of an alternative theory of consumer choice under risk, which they termed "prospect theory," which integrates psychological effects. Their purpose in formulating prospect theory was twofold: one, to devise a model that

altered the tenets of expected utility theory as little as possible, and two, to account more fully for the systematic and specific ways that judgment departs from perfect rationality.

The less-than-full rationality inherent in the Allais paradox provided a solid starting point from which Kahneman and Tversky extended research on irrational consumer behavior. Not surprisingly, their initial inquiries addressed the Von Neumann - Morgenstern axioms of rational choice on which expected utility is principally based. Kahneman and Tversky began by investigating ways that consumers might violate these principles in the process of decision-making.

Assuming that people know how they would actually behave in real-world situations of risky choice, they administered a questionnaire asking hypothetical questions involving monetary gambles. Their subjects were a broad sample of undergraduates at the University of Stockholm and the University of Michigan. The choices identified by their subjects appear discordant with the expectations of expected utility theory. From their data, they noticed four general areas where decisions appeared to violate rational choice axioms (Tversky and Kahneman, 1992).

- *Framing Effects*

  Rational choice theory assumes invariance. That is, the order of desirability between two prospects should not depend on the order or formulation in which the prospects are presented. Contrary to this, subjects seem to show inconsistent preferences based solely on how the prospects are presented (i.e. in terms of gains or losses).

- *Nonlinear Preferences*

  The expectation principle states that the utility of a risky prospect is linear in outcome probabilities. Yet, subjects show, for example, that their utility gained from a

probability change of 0.99 to 1.0 is greater than their utility gained from a probability change of 0.33 to 0.34.

- *Risk seeking*

Risk-averse behavior has traditionally been assumed to pervade choice under uncertainty. Yet, subjects display risk-seeking choices in two specific instances. First, people sometimes prefer a small chance to win a large payoff to the expected value of that gamble. Second, risk seeking is prevalent in situations where people face either a certain loss or a larger loss of substantial probability.

- *Loss aversion*

A particularly striking phenomenon of choice under risk is the tendency for potential losses to loom more ominous in absolute magnitude than potential gains of the same size. The observed asymmetry in these differences is far too large to be explained solely by income effects. Loss aversion implies that the value function of the consumer abruptly changes slope at their current reference level, so that people dislike even small-scale risk (Rabin 1998). The standard assumption of a concave utility function is inconsistent with loss aversion tendencies. A reference-based kink (evident at the axis in the value function of *Figure 5*) is required to explain such risk preferences.

These areas of irrational behavior led Kahneman and Tversky to draw significant conclusions regarding the *actual* decision-making preferences of subjects. They hypothesized a theory with a value function that is concave in the domains of gains and convex for losses, and also steeper in the domain of losses than of gains, i.e.:

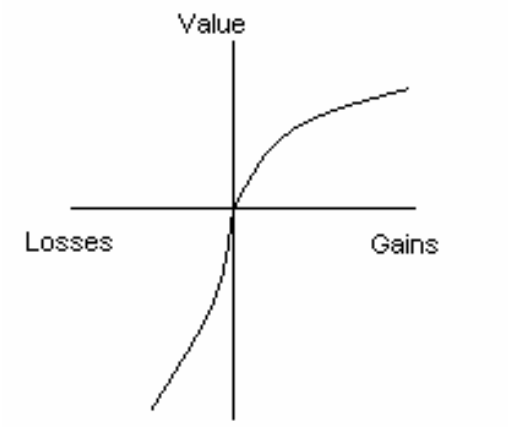


Figure 5.
A hypothetical value function

Additionally, prospect theory assumes a notion of reference dependence built into the utility function. The notion of reference dependence suggests that movements along the utility function are perceived as changes from a certain reference point, which in this case is the origin. The KT value function reflects the belief that the carriers of utility are gains and losses relative to a specific and personal reference point, and not in terms of final states of wealth, as assumed by the EUT model. This suggests that consumers are more sensitive to changes rather than to absolute levels.

Prospect theory advanced unique insights and detailed mathematical assumptions into a new version of risky choice theory. But at a simpler level, it merely incorporates human aspects into a process previously considered quite mechanical. The responses to Kahneman and Tversky's findings (1979) were usually positive, although not devoid of criticism. Some economists conjectured that expertise and learning might mitigate the findings of prospect theory shifting the view of consumer behavior back toward a traditional view of rationality. If economic activity is performed by specialists or an individual is repeatedly exposed to a particular task, the assumptions of classical rationality are believed to fare much better (Rabin 1998). Varieties of evidence have both supported and dispelled this notion. For example, a forthcoming article by List

(2003) presents findings that indicate consumers with extensive market experience tend to act more in accord with neoclassical theories of choice, while inexperienced consumers make decisions conforming to the predictions of prospect theory. Further, Richard Thaler (1981) provides a strong summary of ways in which he has noticed anomalous behavior in decision-making under uncertainty. He even challenges the unconvinced reader to pose his examples to others, so long as they are "*non-economist*" friends. Such a stipulation may indicate that even Thaler, an ardent supporter of an alternative model of consumer choice, questions how *expertise* may affect cognitive anomalies and subsequent irrational behavior. Despite the mounting evidence that supports various behavioral economic theories, these examples highlight the need to specify particular circumstances where neoclassical expectations of consumer behavior are still appropriate.

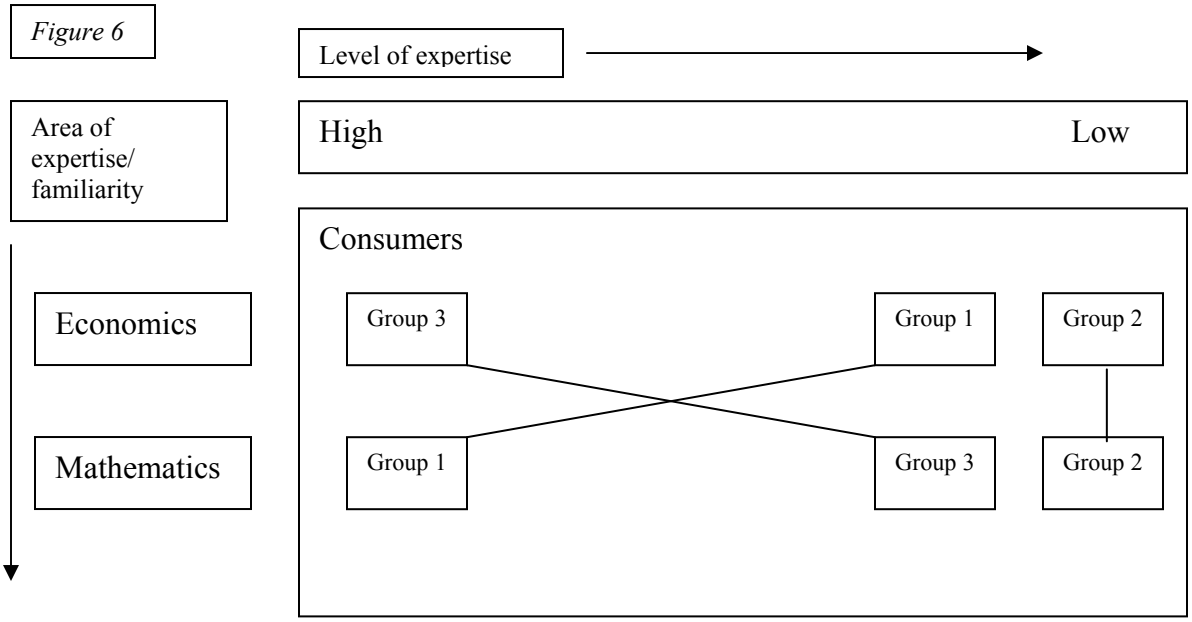
II. Introduction and Methodology

Kahneman and Tversky theorize that prospect theory represents a stable preference structure, but it seems natural to inquire whether certain individuals may vary significantly in their proneness to irrational thinking. Or, perhaps there are consumers less prone to the use of heuristics that lead to erroneous choices under uncertainty or risk. As List (2003) has provided marketplace evidence that indicates experienced individuals act according to traditional axiomatic rationality, I inquire whether a similar finding might occur among subjects with varying expertise in pertinent subjects, such as mathematics or economic theory.

The treatments here reexamine and extend the work of Kahneman and Tversky (1979). This study closely replicates several elements of the original survey study by

Kahneman and Tversky that underpins their formulation of prospect theory. It differs, however, in that subjects were specifically chosen on the basis of their academic training in particular disciplines, specifically in mathematics and economics. The aim was to examine how students with varying degrees of exposure to differing areas of expertise may exhibit choice tendencies that more closely or less closely support neoclassical (rational) choice theory or prospect theory. All participants were junior or senior undergraduate students, and their selection to participate in the questionnaire was based solely on their declared academic major. Group 1 consisted of students majoring in science or mathematics[4]. Group 2, which most closely resembles the control group, consisted of all other "non-science" liberal arts majors who had taken relatively little coursework in science, mathematics or economics[5]. Group 3 consisted of students majoring in economics. This design is depicted graphically in *Figure 6.*

Figure 6



[4] For simplicity, Group 1 will be referred to as the *science* group.
[5] For simplicity, Group 2 will be referred to as the *humanities* group.

Prior to administering the risky-choice questionnaire, I hypothesized that there would be noticeable differences in the risky choice tendencies across these three groups. I anticipated that the cognitive anomaly effects so prevalent in the KT data would be attenuated for the economics group and the science group. Additionally, I expected to see a higher rate of internal consistency in answers for the science group, as well as the economics group. For example, I feel it would not be surprising to see a subject familiar with advanced mathematics to display a greater tendency to identify logically consistent preferences. Still, given the existing research on both sides of the current debate over economic rationality, results indicating pervasive irrationality would not have been surprising.

PARTICIPANTS

Research participants (N_{CH} = 100) were junior or senior undergraduate students enrolled at the University of North Carolina-Chapel Hill. First-year and sophomore students were not eligible regardless of their declared major because these students typically lack the coursework experience that was the critical moderator in this study. Participants were solicited via a university informational email that advertised the opportunity to participate in an economics thesis questionnaire in exchange for a $10 participant reward. Out of over 500 potential subjects, 100 students were selected to serve as participants. Prospective participants were screened only according to their academic major(s). One-third of the 100 enrolled participants were economics or business majors (33)[6], one-third were science or math majors (34)[7], and one-third were

[6] Some subjects were both economics and business administration majors
[7] These included, in no particular proportion: math, physics, chemistry, applied science, geology, biology (BS only), clinical lab science, and computer science.

non-science, liberal arts majors (33)[8]. 47 of the participants were female and 53 were male, although the sex of the participant was not used as a selection criterion, nor was sex an anticipated moderating variable in the analysis.

Kahneman and Tversky do not discuss the composition of their subject pool in their article. They note that their subjects were undergraduates at the Universities of Michigan and Stockholm. Upon direct query, Kahneman elaborated only that the subjects "were from quite varied backgrounds[9]." Given the academic composition of these universities, it is likely that their participant groups did not contain proportionally as many economics students or science majors. It seems most reasonable that the majority of their participants would correspond to the "humanities" group of the current study. Although downplayed in the discussion by Kahneman and Tversky, the composition of their testing pool is not a trivial concern, particularly as it relates to the goals of the current study.

PROCEDURE

The questionnaire was administered during half-hour testing sessions over a four-day span (11/17/03 to 11/20/03). Participants were first read an informed consent form that outlined the purpose of the study, what was expected of them, and their rights as a testing subject. Subjects were told only that the questionnaire was designed to research economic decision-making, that there were no correct or incorrect answers, and that they should concentrate on using rationality and personal preferences to make their selections. Participants were instructed that they would not be allowed to leave before the end of the

[8] These majors included, in no particular proportion: Spanish, political science, psychology, journalism, education, fine art, anthropology, philosophy, communication studies, history, geography, women's studies, recreation studies, English, and sociology.
[9] This description was provided from direct e-mail correspondence between Kahneman and myself.

half-hour testing session, thus minimizing any inclinations for the subjects to respond hastily or to disturb others while exiting the testing session.

The questionnaire consisted of ten paired questions and two individual questions. These pairs were separated and randomly arranged in the questionnaire, though in the following results section, they are repaired and reordered for a more coherent presentation. Following completion of the questionnaire, subjects provided information about their academic standing, age, sex, degree type, major(s) and/or minors of study, and the numbers of classes taken in various fields of math, science, and economics.[10] Upon completion of the half-hour testing period, participants were then compensated $10 for successful completion of the questionnaire. All 100 enrolled subjects successfully completed the questionnaire.

The procedures and testing questions were intentionally meant to closely mirror that of Kahneman and Tversky (from herein, referred to as KT). The only differences were the length of the questionnaire (KT asked 12 questions per subject), the cash incentive to participate, and the additional personal information that was solicited in conjunction with each set of responses. By creating a situation with a very limited number of differentiating variables, any variations can more accurately be attributed to differences in the testing subjects and their inherent personal qualities.

[10] These subjects included: applied science, biochemistry, biology, biomedical engineering, business administration, chemistry, clinical lab science, computer science, economics, math, operations research, philosophy, physics, psychology, statistics, and "other."

III. RESULTS

This section will be presented as follows. A pair of hypothetical prospects will be presented from the original KT testing questionnaire. In their study, each pair of prospects illustrates a specific violation of the expected utility axioms. The original KT results will be presented in the top row displaying the percentage of respondents that chose each prospect. The number of respondents who answered each problem is denoted as N. Following the KT data (Kahneman & Tversky 1979), the percentages for each of the three test groups (1=Science, 2=Humanities, and 3=Economics) and the cumulative responses are presented[11]. The KT percentages that are noted with a " * " are significant at the 0.01 level. The significance of the KT data will then be briefly discussed, followed by a broad summary of the current results. Any prospect pairs whose results significantly vary from the prospect theory findings of Kahneman and Tversky will be elaborated upon in further detail in section IV. For a complete breakdown of the statistical differences of responses between groups, please see the *Appendix*.

Problems 1 and 2 replicate Allais' paradox and were presented in the aforementioned introduction and so the anomalous results will not be elaborated here. However, for the sake of consistency and review, the problems are as follows.

[11] The individual group results and cumulative results are distinguished by N_1, N_2, N_3, and $N_{CH.}$

Problem 1: Choose between

A: \$2,500 with probability .33,
\$2,400 with probability .66,
\$0 with probability .01;

Expected Value (EV) = \$2,409[12]

B: \$2,400 with certainty.

EV = \$2,400

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT}=95	18	82*	
N_1=34	47	53	41
N_2=33	48	52	39
N_3=33	42	58	52
N_{CH}=100	46	54	44

Problem 2: Choose between

C: \$2,500 with probability .33
\$0 with probability .67;

EV = \$825

D: \$2,400 with probability .34,
\$0 with probability .66.

EV = \$816

Group	% Choosing C	% Choosing D
N_{KT} =72	83*	17
N_1=34	76**	24
N_2=33	64	36
N_3=33	76**	24
N_{CH}=100	72	28

As previously discussed, the KT results show that subjects ignored the substitution axiom by reversing their preferences in prospects from *B* to *C*. Kahneman and Tversky partially attributed this to the certainty effect, which expresses the tendency to overweight outcomes that are certain to occur over those that are merely probable. While the majority of subjects in the current study still preferred option *B*, they did so to a significantly lesser degree than the KT subjects. The current subjects' preferences in Problem 2 are more consistent with the KT results and do not indicate a significant difference.

[12] The expected value of each prospect is noted in bold; these values were not included in the original questionnaire.

** This denotes preference differences that are significant at the .05 level

A demonstration of the same phenomenon is presented in Problem 3 and Problem 4, now in the form of two-outcome gambles.

Problem 3: Choose between

A: ($4,000, .80) B: ($3,000).

EV = $3,200 **EV = $3,000**

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT}=95	20	80*	
N_1=34	12	88**	71
N_2=33	12	88**	56
N_3=33	42	58	42
N_{CH}=100	22	78	57

Problem 4: Choose between

C: ($4,000, .20) D: ($3,000, .25).

EV = $800 **EV = $750**

Group	% Choosing C	% Choosing D
N_{KT} =72	65*	35
N_1=34	76**	24
N_2=33	58	42
N_3=33	85**	15
N_{CH}=100	73	27

Problems 3 and 4 show interesting results. In Problem 3, we see the certainty effect in full display, with subjects in the KT study preferring the certain prospect to the risky prospect at a rate of four to one. The current study (abbreviated from herein as *CS*) subjects showed a similar preference as an entire group, but the economics group alone displayed a much higher tendency to favor the risky prospect *A* than either of the other groups (42%, versus 12%, 12%). Additionally, KT note that over half of their subjects selected an *irrational pattern of preferences*[13] inconsistent with expected utility theory[14].

[13] *irrational pattern of preferences* refers to a pattern of prospect selection that indicates a violation of expected utility theory axioms.

To see this, set $u(0) = 0$, and recall that the choice of *B* implies $u(3{,}000)/u(4{,}000) > 4/5$, whereas the choice of *C* implies the reverse equality (this is true for the selection preference of *A* and *D* as well). The CS, however, shows that while over half of the entire group selected an irrational preference pattern, the economics group displayed a tendency to choose irrationally less than half of the time (42%).

There are two notable differences here, both pertaining to the choices of the economics group. First, the percentage of economics subjects who selected the risky prospect in Problem 3 was more than double that of the KT subjects, and more than triple that of science and humanities groups. This could indicate that the economics group is less susceptible to the certainty effect or that they are more risk-seeking as a group. Second, less than half of the economics subjects chose an irrational pattern of preferences, while an average of 64% of the non-economics subjects chose irrationally. For this set of questions, the economics group was less prone to violate the substitution axiom of rational choice.

This general trend occurs in choices with non-monetary outcomes as well, as demonstrated in the results for Problems 5 and 6.

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[14] Kahneman and Tversky note that over half of the respondents chose an irrational pattern of preferences that violated expected utility theory, but they do not cite the exact percentages for most of the problem pairs. The current study cites these statistics under the table heading, " % Choosing inconsistently."

Problem 5: Choose between

A: 50% chance to win a three-Week tour of England, France, And Italy;

B: A one-week tour of England, with certainty.

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =95	22	78*	
N_1=34	44	56	53
N_2=33	27	73**	45
N_3=33	39	61	45
N_{CH}=100	37	63	48

Problem 6: Choose between

C: 5% chance to win a three-week tour of England, France, and Italy;

D: 10% chance to win a one-week tour of England.

Group	% Choosing C	% Choosing D
N_{KT} =72	67*	33
N_1=34	76**	24
N_2=33	64	36
N_3=33	73**	27
N_{CH}=100	71	29

In this pair of problems, notable differences occur between the science group and again in the economics group, relative to the KT results. In Problem 5, most of the KT respondents steered away from the risky prospect *A* in favor of the certain prospect *B*, although this prospect had a smaller payoff. This finding supports their assertion that consumers are prone to the certainty effect. In the current study, however, the percentage of respondents in the economics and science groups that chose the risky prospect *A* to the certain prospect *B* was nearly double that of the KT subjects. The humanities group presented a result roughly paralleling the results of the KT study (27% vs. 22%, respectively).

To illustrate that the substitution axiom is violated even when a certain prospect is not an alternative, Kahneman and Tversky offered the following pair of problems:

Problem 7: Choose between

A: (6,000, .45) **EV = $2,700**

B: (3,000, .90). **EV = $2,700**

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =66	14	86*	
N_1=34	6	94**	71
N_2=33	9	91**	73
N_3=33	12	88**	67
N_{CH}=100	9	91	71

Problem 8: Choose between

C: (6,000, .01) **EV = $60**

D: (3,000, .02). **EV = $60**

Group	% Choosing C	% Choosing D
N_{KT} =72	73*	27
N_1=34	76**	24
N_2=33	76**	24
N_3=33	85**	15
N_{CH}=100	79	21

The KT results suggest irrational differences in preferences when probabilities are substantial versus tiny. In Problem 7, subjects face a choice between two large payoffs ($3,000 and $6,000) at substantial probability levels (45% and 90%). Although option *B* is not certain to occur, subjects still overwhelmingly preferred this "safer" prospect to the more risky one (*A*). Yet when the same large payoffs are offered but instead with very small chances of occurrence (.1% and .2%), subjects reversed their preferences and chose the riskier of the two prospects. Apparently, when the odds of winning are substantially small for both prospects, subjects find it easier to choose the riskier prospect.

The CS findings closely mirrored the KT data; additionally, there were no significant differences in preferences or in the frequency of irrational choice patterns between the three sub-groups.

The problems in the initial KT study all posed prospects in the domain of gains. That is, the subjects were only forced to choose between prospects that offered various winnings, and although some of the gains were not certain, there was no chance that the subject could lose anything if their prospect did not pay off. A logical extension of these problems would be to pose the same prospect pairs, but in terms of losses rather than gains. Expecting that preferences would change in the domain of losses (Markowitz 1952) Kahneman and Tversky did exactly this and altered Problems 3 and 4 such that they offered a situation of risky losses instead of risky gains.

Problem 3: Choose between

A: ($4,000, .80) B: ($3,000).

EV = $3,200 **EV = $3,000**

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =95	20	80*	
N_1=34	12	88**	68
N_2=33	12	88**	64
N_3=33	42	58	36
N_{CH}=100	22	78	56

Problem 3*: Choose between

A: (-$4,000, .80) B: (-$3,000).

EV = -$3,200 **EV = -$3,000**

Group	% Choosing A	% Choosing B
N_{KT}=95	92*	8
N_1=34	62	38
N_2=33	64	36
N_3=33	48	52
N_{CH}=100	59	41

Problem 4: Choose between

A: ($4,000, .20) B: ($3,000, .25).

EV = $800 **EV = $750**

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =95	65*	35	
N_1=34	76**	24	68
N_2=33	58	42	52
N_3=33	85**	15	82
N_{CH}=100	73	27	67

Problem 4*: Choose between

A: (-$4,000, .20) B: (-$3,000, .25).

EV = -$800 **EV = -$750**

Group	% Choosing A	% Choosing B
N_{KT}=95	42	58
N_1=34	38	62
N_2=33	48	52
N_3=33	27	73**
N_{CH}=100	38	62

The KT subjects display what is called a "reflection effect," which refers to a reversal of preferences when the prospect flips from the positive (gains) to the negative (losses) domain. Evidently, the prospect of taking a loss that is certain to occur is painful enough to cause many subjects to prefer a risky prospect, where they at least have some chance of avoiding any loss. The responses of the KT subjects have several implications. First, Kahneman and Tversky noted that risk-aversion in the positive domain is often accompanied with risk-seeking in the negative domain. For instance, Problems 3 and 3* indicate that a preference for the certain $3,000 gain is reversed when it becomes a certain $3,000 loss, and the chooser has the alternate prospect of losing $4,000 with a risk of .80. Despite the later prospect having a lower expected value (-$3,200 vs -$3,000), the KT subjects overwhelmingly chose the risky prospect when faced with a situation of

losses. Such strong preferences led Kahneman and Tversky to note that the certainty effect continues to exert an influence in the domain of losses as well as the domain of gains. However, in the domain of gains, the certainty effect causes subjects to overweight the risk-free prospect, while in the domain of losses, the same certainty causes subjects to overweight the risk-seeking prospect. Thus, an outcome that is certain is not generally preferred—it depends on whether that outcome is a gain or a loss.

The CS subject choices also exhibit a reflection effect, although it is significantly less pronounced than for the KT subjects. In particular, the economics group chose the risky prospect in Problem 3* (-4,000, .80) less than half of the time (48%), while the humanities and science groups chose this prospect at a frequency of nearly two-thirds, and the KT subjects chose at an astounding rate of 92 percent. Note that these preferences indicate the economics students preferred the prospect with the higher expected value (*B*), while every other group majority (including the KT subjects) chose the prospect with the lower expected value (*A*). Furthermore, 66 percent of the humanities and science subjects displayed a pattern of preferences that exhibited a reflection effect; only 36 percent of the economics subjects displayed this tendency in this problem pair, indicating a significant difference in the amount of consistency exhibited in these choices.

Problems 4 and 4* also indicate preferences in the economics group that vary from the other two groups and the KT subjects. In Problems 4 and 4*, the economics group chose the prospects with the higher expected value more frequently than either the of the other groups. Contrary to Problems 3 and 3*, the economics group overwhelmingly displayed a reflection effect in Problems 4 and 4* (36% versus 82%, respectively). Upon first glance, these statistics seem to contradict each other, in that

they relate very different tendencies for economics subjects to display a reflection effect in their choices. However, in Problem 4*, prospect *B* has a higher expected value than prospect *A* (-750 versus -800, respectively), while in Problem 3* the opposite is true. Thus in this problem pair as well, the economics group chose the prospects with the higher expected values more frequently than did either the science group, the humanities group, or the KT group. Therefore the economics group did display a reflection effect in their preferences, but only in such instances where the reflection effect choice coincided with the choice of highest expected value.

The Isolation Effect

Another heuristic used in decision-making occurs when people disregard commonly shared parts of prospects and isolate the differences. Using only the differing components to distinguish between alternatives may lead to inconsistent choices because there are multiple ways to decompose prospects, and different decompositions lead to different preferences. Kahneman and Tversky (1979) termed this phenomenon the *isolation effect* and is illustrated in the following pair of problems:

Problem 9: Consider the following two-stage game. In the first stage, there is a 75% chance to end the game without winning anything and a 25% chance to move to the second stage where you then have a choice between:

A:	a sure win of $30	B:	an 80% chance to win $45.
	EV = $30		**EV = $36**

Your choice must be made before the game starts, i.e. before the outcome of the first stage is known. Please indicate the option you prefer.

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =85	74**	26	
N_1=34	50	50	38
N_2=33	70	30	42
N_3=33	55	45	58
N_{CH}=100	58	42	46

Problem 10: Choose between

C: ($30, .25) **EV = $7.50**

D: ($45, .20). **EV = $9**

Group	% Choosing C	% Choosing D
N_{KT} =85	42	58
N_1=34	29	71
N_2=33	33	67
N_3=33	15	85**
N_{CH}=100	26	74

Problem 9 presents a situation where the final outcome is dependent not only on the selection between a sure prospect (*A*) and a risky prospect (*B*), but also on the likelihood that the first stage will be successfully completed, of which there is a 25 percent chance. When considering this fact, prospect *A* actually offers a .25 probability of winning $30 and prospect *B* offers a .25*.80 = .20 probability of winning $45. Thus, Problems 9 and 10 offer logically identical gambles. However, the choices of the KT subjects do not share this equivalency. Nearly three-fourths of the KT subjects chose prospect *A*, in accordance with the certainty effect. Although prospect *C* offers an identical payoff and probability, the same subjects chose option *D* more frequently in Problem 10, thus displaying an inconsistent pattern of preferences. Clearly, subjects did not view these two problems in an identical fashion. While it is difficult to expect that subjects would see these problems as equivalent, the rationality axioms of expected utility theory suggest that we should. The isolation effect explains why we may violate

the axiom of invariance and allow the framing of probabilities to distort the consistency of our preferences. When analyzing the prospects in Problem 9, it seems that subjects ignored the information regarding the first phase of the game and focused only on the different prospects at the end of the game. In doing so, the 25% chance of moving to the second stage was never mentally accounted for when choosing between prospects *A* and *B*.

The CS results display tendencies across the three groups that lie in the same general direction as the KT data, with two notable differences. First, in Problem 9 the science and economics groups chose the certain prospect (*A*) at a significantly lesser frequency than the KT subjects and the humanities group. Secondly, in Problem 10, only 15 percent of the economics group subjects chose prospect *A* over *B*, whereas the KT, science, and humanities subjects did this far more frequently (42%, 29%, 33%, respectively). These two results indicate that subjects from the economics group were more likely to choose the prospect with the highest expected value than members of any other testing group.

From an axiomatic perspective, the previous problem illustrates a violation of invariance, which states that the order or manner in which prospects are described should have no bearing on their value or preference. On a simpler level, it may raise questions about the human capacity to attend to and process statistical information adequately and intelligently. To highlight other instances where invariance is violated, the KT study offers the following problems.

Problem 11: In addition to whatever you own, you have been given $1,000. You are now asked to choose between

A:	($1,000, .50),	B:	($500).
	EV = $500		**EV = $500**

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =70	16	84*	
N_1=34	18	82**	47
N_2=33	30	70**	55
N_3=33	52	48	39
N_{CH}=100	33	67	45

Problem 12: In addition to whatever you own, you have been given $2,000. You are now asked to choose between

C: (-$1,000, .50), **EV = -$500**

D: (-$500). **EV = -$500**

Group	% Choosing C	% Choosing D
N_{KT} =68	69	31
N_1=34	53	47
N_2=33	61	39
N_3=33	45	55
N_{CH}=100	53	47

The KT subjects showed a strong preference for prospect *B* in Problem 11 and for prospect *A* in Problem 12. In terms of the expected value of final states, all four of these prospects are equivalent and position the chooser at $1,500 regardless of the choice made. Problem 11, though, frames this outcome as an upward gain starting from $1,000 while Problem 12 frames the final state as a downward loss starting from $2,000. Prospects *A* and *C*, when integrated with their respective bonuses of $1,000 and $2,000, both offer the final states of $2,000 if the chooser is lucky and $1,000 if the chooser is unlucky. Conversely, prospects *B* and *D*, when integrated with the same bonuses both lead to the same final state of $1,500 with certainty. Many subjects violated the invariance axiom though, by choosing *B* first (which offers a final state of $1,500) and then *C* (which offers an unsure final state of either $2,000 or $1,000). The KT results show that subjects evidently did not integrate the bonus with the prospects. Additionally,

these results mirror previous studies that indicate a reflection effect occurs that indicates risk-aversion in the domain of gains and risk-seeking in the domain of losses.

To understand how the KT results clash with expected utility theory, first recognize that EUT states that the utility of owning the amount of $1,500 should be the same, whether it was reached from a prior wealth of $1,000 or $2,000. The choice to own $1,500 versus even chances of owning $1,000 or $2,000 should be independent of whether one currently owns the smaller or larger amounts. With the added assumption of risk-aversion, expected utility theory states that one should always prefer the certain option of owning $1,500. Problems 11 and 12 illustrate that this preference is not always manifest; it appears that if the individual owns the smaller amount, he will choose the certain prospect, but if he owns the larger amount, he will choose the risky prospect[15].

The CS data indicate notable differences. The averaged results of the science and humanities group indicate preferences that are not significantly different from the KT preferences. That is, these subjects generally preferred the risk-less prospect *B* and the risky prospect *C*, to their respective alternatives, in accordance with the certainty effect. However, in Problem 11, over half of the economics group (52%) chose the risky prospect *A* whereas none of the other groups even approached the frequency of this

[15] Kahneman coined the term, "peak-end rule" to describe the psychological phenomenon illustrated in these problems. This rule maintains that an individual's level of happiness is not determined by her final state of income, but instead is largely a result of whether her level of income is increasing or decreasing. The peak-end rule may explain why the current mindset of many American consumers is relatively negative, despite indications that the nation's economy is on an upturn. Our GDP is four trillion dollars richer than it was a decade ago, yet the experience of the late 90's boom and then the resulting crash and recession of 2001 may sour our economic affect. Had we experienced only mild economic growth during the past decade, out general level of happiness might now be greater than if we hadn't experienced a roller coaster of wealth. Such a notion sharply challenges a basic tenet of economic theory and calls into question whether we may assume that being richer truly does make the consumer "better off" or happier. While an individual may experience "happiness" as their wealth is actually increasing, any gains in wealth may quickly be dissipated once that rise in wealth has stopped, and the consumer quickly adapts to her new circumstances. The peak-end rule implies that the first derivative matters more than the absolute level. Hence, it may be more appropriate to understand happiness not in terms of current income (or utility), but rather due to the direction from which a consumer obtained that level.

response (16, 18, 30%). Further, in Problem 12, in a situation of potential loss, over half of the economics group (55%) chose the certain loss of prospect *D* over the risky loss of prospect *C*. Again, this trend is contrary to the general tendencies of the KT subjects (and somewhat discrepant with the tendencies of the humanities and science groups, as well), who preferred to choose the risky prospect *C*, exhibiting risk-seeking behavior in the domain of losses.

These three subgroups differed significantly in the consistency of their patterns of preferences, as has been the situation in several of the aforementioned problems. Only a third of economics subjects displayed a pattern of preferences consistent with a reflection effect. The frequency of science subjects who displayed this irrational tendency was nearly half (47%) and even higher in the humanities group (55%).

Other research (Gregory, 1983; Hammack & Brown, 1974) has extended the study of how framing outcomes in terms of costs instead of losses may alter our perception and subsequent preference of those outcomes. The notion of loss aversion caused Kahneman and Tversky to hypothesize that negative outcomes framed as a *cost* would be preferred to equivalent outcomes that are framed as a *loss*. To illustrate this point, they offer the following questions[16].

Problem 11: Would you accept a gamble that offers a 10% chance to win $95 and a 90% chance to lose $5? **EV = $5**

Problem 12: Would you pay $5 to participate in a lottery that offers a 10% chance to win $100 and a 90% chance to win nothing? **EV = $5**

Problems 11 and 12 offer equivalent situations of expected gains and losses, though Problem 11 offers a situation where the negative outcome is framed as a loss, and in

[16] Kahneman and Tversky used these problems in a later study, entitled "Choices, Values, and Frames," published in 1984.

Problem 12, the negative outcome is framed as a cost or payment. In KT's survey, a total of 132 undergraduates answered these questions, and 55 of their respondents indicated different (inconsistent) preferences (42%). Of these 55 subjects, 42 accepted the opportunity to play $5 lottery in Problem 12, and at the same time rejected the opportunity posited in Problem 11. The KT data suggest that a fairly high number of their subjects (32%) irrationally altered their preferences according to the way in which the negative outcomes were framed.

There are noteworthy similarities and differences in the CS findings. The humanities group, which I presumed to be the most similar composition to the KT subject pool, chose inconsistently at a frequency of 30 percent, which is the closest of the three subgroups to the results of the KT group. Following this, the science group chose inconsistently at a rate of 21 percent, and the economics group was the least inconsistent of the three subgroups, choosing irrationally at a rate of 15 percent. The ordering of consistent preference patterns is beginning to show a pattern itself, with the economics group typically displaying the most consistent responses followed by the science group and then the humanities group.

Monetary situations are not the only instances where framing effects can irrationally alter an individual's perception of an outcome. In the below problems, Kahneman and Tversky construct a set of alternatives that deals with "lives saved" versus "lives lost."

Imagine that the US is preparing for the outbreak of an unusual airborne 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 programs are as follows:

Problem 13:
If Program A is adopted, 200 people will be saved.
EV = 200 lives saved; 400 lives lost

If Program B is adopted, there is a one-third chance that 600 people will be saved and a two-thirds chance that no people will be saved.
EV = 200 lives saved; 400 lives lost

Group	% Choosing A	% Choosing B	% Choosing inconsistently
N_{KT} =152	72*	28	
N_1=34	62	38	18
N_2=33	67	33	36
N_3=33	58	42	21
N_{CH}=100	62	38	25

Problem 14:
If Program C is adopted, 400 people will die.
EV = 200 lives saved; 400 lives lost

If Program D is adopted, there is a one-third chance that no people will die and a two-thirds chance that 600 people will die.
EV = 200 lives saved; 400 lives lost

Group	% Choosing C	% Choosing D
N_{KT} =155	22	78*
N_1=34	44	56
N_2=33	36	64
N_3=33	42	58
N_{CH}=100	41	59

As in previous pairs of problems, prospects *A* and *B* are equivalent in terms of final states to prospects *C* and *D*. In fact, Problems 13 and 14 have identical outcomes. They are merely worded differently. Problem 13 is framed as a situation of "lives saved" or gains, while Problem 14 is framed in terms of the number of deaths, or "lives lost." Each prospect pair has an identical expected value (e = 200) and identical probabilities. As in their monetary examples, Kahneman and Tversky found that most subjects (72%) favored the certain prospect in the domain of gains and the majority (78%) also favored the risky prospect in the domain of losses. While this problem illustrates the differences in risk-seeking versus risk-loving behavior, it highlights even more the importance of framing effects. Clearly, the large reversal in preferences from the certain prospect to the risky prospect indicates an irrational choice that may be attributed to the way the

prospects were described. Kahneman and Tversky do not cite the specific percentage of respondents who chose this exact choice pattern, but merely note that "the failure of invariance is both pervasive and robust…and it is as common among sophisticated respondents as among naïve ones" (Kahneman & Tversky 1984).

The CS results call into question the validity of this statement. The CS results share the same direction of the KT data; that is, more subjects generally preferred the certain prospect in Problem 13 and the risk-seeking prospect in Problem 14. However, the magnitude of these preferences is far less, and the frequency of irrational preferences is not equally pervasive across the three subgroups. The group making the most frequent inconsistent choice pairs was the humanities group, with 36 percent of the respondents choosing in such a manner. The economics and science group respondents chose irrationally at rates of 21 and 18 percent, respectively—both rates are moderately less than that of the humanities group, and likely less than the KT subject rate, given the trend of findings in other problems cited throughout this study.

The final question of the survey was not part of past questionnaires administered by Kahneman and Tversky. It differs in that it lacks a paired question to illustrate an inconsistency, and subjects were asked to provide their own answer to the question, rather than select from provided choices.

Problem 15: A casino offers you a game that involves the toss of a single coin. If the coin comes up heads, you must give the casino $20. If the coin comes up tails, the casino gives you $X.

You may only play this game one time. What is the minimum value of $X that you would accept in order to play this game?

A gambler willing to accept exactly even odds should accept this bet if the value of *X* is $20. Any chosen value that is less indicates that the decision maker is risk-loving, as he is willing to accept a bet in which the expected value of his winning is less than the

expected value of his loss. By the same logic, a gambler is risk-averse if he demands a value that is greater than $20.

The responses to this question were extremely varied. Many respondents provided answers that were near $20, but an equally large number of respondents provided answers that ranged well into the area of $50 to $100 or greater. The mean, median, and modal responses of the three groups are as follows[17].

	Group	Mean	Median	Mode
Science	N_1=34	$59.16	$40.00	$40.00
Humanities	N_2=33	$54.75	$40.00	$40.00
Economics	N_3=33	$42.28	$30.00	$30.00

All three groups provided answers that indicate extreme risk-aversion. However, the mean accepted value of the economics group was significantly lower than the mean accepted value of either the science group or the humanities group, which did not differ significantly relatively to each other. The median and modal values also support the tendency of economics majors to willingly accept a lesser value to play this gamble; it is the responses of the economics majors that are closest to the expected value of the gamble, which is the value that expected utility theory would promote as the rational answer.

IV. Discussion

The aforementioned problems represent questions involving simple risks and outcomes of various values. The purpose of constructing these hypothetical situations was to expose basic attitudes toward risk and value that may challenge the classical

[17] Outliers were excluded from the calculation of the mean values.

notions of decision-making under risk. Through their surveys, Kahneman and Tversky, and many others who have followed in their pioneering footsteps, have concluded that the classical theory of risky choice (expected utility theory) is a sub-optimal predictor of the behavior of consumers faced with choices between risky prospects. They have illuminated a number of cognitive anomalies that seem to indicate that mental processes do not operate in a normative or idealistically rational fashion. From their study of consumer choice and cognitive processes, they devised prospect theory to serve as a better descriptive model of the choices of most economic agents (Kahneman & Tversky 1979).

The goal of this study was not to discredit the findings of Kahneman and Tversky or to devalue prospect theory. Rather, the purpose of this study was to identify whether certain types of individuals may not be as "irrational" as the Kahneman and Tversky findings predict.

The results of the current study indicate notable differences in the pattern of choices across the three subgroups (group 1-science; group 2-humanities; group 3-economics) and the overall group results in comparison to those reported in the initial Kahneman and Tversky study (1979). In nine of ten comparable problem pairs, the economics group displayed choice patterns that were either significantly different from the KT data or to one of the other subgroups. Several instances occurred where the results from the science group significantly differed from those reported by the KT study, but these discrepancies occurred less frequently than they did for the economics group. The choices of the humanities group did closely approximate the broad findings of the KT data.

There are three observable trends. First, the subjects in the current study differed in their expression of risk-seeking and risk-averse behavior. Some groups tended to be more risk-averse in the domain of gains and risk-seeking in the domain of losses while members of other groups on average displayed the reverse inclination. Secondly, subjects differed according to the frequency in which they chose the prospects with the highest expected value. Finally, subjects exhibited varying degrees of inconsistent patterns of preferences. The frequency of inconsistent choice patterns is indicative of irrational choice behavior.

The most notable difference that occurred in several of the problems was the tendency for the economics students in the current study to be relatively more risk-seeking in the domain of gains and relatively more risk-averse in the domain of losses. This finding directly contradicts the predictions of prospect theory, in which the certainty effect and loss aversion account for risk-averse behavior in the domain of gains and risk-seeking behavior in the domain of losses. These differences are particularly notable in problems 3, 4, 3*, 4*, 8, 11, 12, 13. Each of these demonstrates that the economics group, more than either of the other groups, preferred the relatively risky-prospect when faced with the potential to gain utility. This tendency was reversed in situations where the subject faced a choice between a certain loss and a risky loss. Here, the economics group tended to choose the certain loss over the risky loss far more frequently than respondents from the other groups. These results paint a picture of economics students as being greater "gamblers" when faced with a situation of earning money or other assets, and simultaneously more conservative (or relatively more risk-averse) than average when faced with a possibility of losing money.

The backbone of expected utility theory lies in the notion of expected value. Specifically, choosing the prospect with highest expected value is analogous to choosing the prospect with the highest expected utility, and this is the fundamental rule in classical choice theory. When problems offer prospects of different expected value, the economics group showed a greater tendency to choose the prospects with the highest expected value, and in many instances, these choices differed greatly from the findings of Kahneman and Tversky. Problems 3, 3*, 4, 4*, 10, 15 each exhibit an instance where economics subjects chose the prospect with the highest expected value a majority of the time, or at the very least, more often than any of the other test groups. To a lesser degree, subjects in the science group occasionally preferred the prospect with the higher expected value, but these differences were sporadic and lesser in frequency than the economics group. The members of the humanities group chose in relative accord with the KT group with respect to how sensitive they were to highest expected values.

A third category of differences regards the frequency of irrational patterns of choice exhibited by the KT group and the three subgroups. In each of the problem pairs, there is a pattern of choice that represents some violation of an axiom of rational choice, such as transitivity or invariance. Irrationality is not evident in any one individual prospect. Rather irrationality becomes evident when certain paired prospect choices do not conform to certain laws of rational choice. It can be concluded that those subjects that displayed a lesser frequency of such irrational choice patterns are more consistent with the standard, expected utility theory.

In most of the problems, the economics group exhibited the lowest level of irrational patterns of choice (3, 4, 5, 6, 7, 8, 11, 12). The science group displayed the lowest frequency of irrational choice in two problem pairs (9, 10, 13, 14) but in one of

these instances, the economics group was nearly equivalent. The humanities group far more consistently chose inconsistent pairs of prospects, suggesting that this group was the most susceptible to making irrational choices when confronted by risk. One possible explanation for this phenomenon becomes evident when we question how these areas of studies, which broadly constitute the "humanities," may differ from fields such as economics or mathematics. Immediately, the different levels of analytical and quantitative skills emphasized in these areas of study seem to be a natural, albeit one-dimensional, explanation for this occurrence.

The limited sample sizes of each subgroup make it difficult to assert definitive conclusions. Statistical significance requires much large samples that would provide larger degrees of freedom. However, the data do indicate notable differences from which I wish to speculate. The behavior of the economics group varies from the other groups in enough problems and at such magnitudes that it seems economics students at UNC respond differently to choices entailing risk than do their counterparts in different disciplines. In my study, economics students use the rule of "highest expected value" far more frequently in choosing between prospects, which is a tendency that places their behavior in line with the neoclassical theory of consumer choice, namely, EUT. Economics students also exhibited the lowest frequency of inconsistent and irrational choice patterns. Overall, it seems reasonable to conclude that Kahneman and Tversky's prospect theory may be an accurate predictive (descriptive) model for most consumers, specifically those that lack expertise in areas related to economic theory or even rudimentary understanding of probability. The classical model of choice has largely been shown to be far less generally applicable than was conventionally believed, but it may still be appropriate for describing the behavior of certain individuals in certain situations,

namely those individuals with expertise in relevant areas, or perhaps those in situations where learning may guide how they adjust their behavior.

My original hypothesis was that there would be noticeable differences in the risky choice tendencies across these three groups, specifically in the economics group. I also hypothesized that the science and economics group would both show higher rates of internally consistent choices than the humanities group. The results of this study seem to support at least the first hypothesis. That is, the irrational behavior apparently so pervasive in the Kahneman and Tversky study seems attenuated in the economics group of the current study. The second hypothesis was supported, though to a lesser degree. The economics group, as predicted, showed higher levels of consistent preferences, but the science group did not exhibit an especially high level of consistent choices, though their preference patterns were more consistent than the humanities group.

In addressing the potential sources of variance in the data, one must first question how the selected subgroups may have differed from one another, and it seems reasonable that at least two possibilities deserve consideration. The first and most obvious difference is that by their junior and senior years, economics students have acquired a unique academic skill-set and methods of analysis that are quite different from that of other academic disciplines. This "economic way of thinking" may inculcate a more formal, rule-based analytical style than other sciences, and especially such areas of liberal arts, as English, history, or fine arts. Nearly all of the economics subjects had taken courses in economic statistics and this may have influenced the economics student's perceptions about problem-solving, especially in regard to the use of expected value and familiarity with the concept of maximization.

It is natural to question whether the male to female ratios in each group were equivalent, and if not, if this might be a significant source of variance. The existing literature has not addressed sex as a significant independent variable in the study of choice under risk, and the present study did not make sex a consideration in the process of subject selection. In fact, the groups did not contain equal ratios of men to women: the science group consisted of 53 percent women, the humanities group 70 percent, and the economics group 21 percent. Did these disproportionate ratios serve as a source of variance, particularly for the heavily male-dominated economics group? To address this question, the survey data were separately analyzed according to sex rather than by area of study. The results of this analysis yielded no significant variations in either the prospect preferences or levels of consistency between males and females, and the sex of the subject was rejected as a significant variable in this analysis.

Certainly, the diverse academic skill sets obtained after two or three years of collegiate academics serves as one potential source of variance. But subscribing purely to an explanation that only emphasizes this difference would entail an assumption that all students entering college studies have more or less equivalent levels of expertise or started from comparable reference points. This assumption seems problematic for obvious reasons, namely that students *do* have extremely varied academic backgrounds when beginning college and numerous other subjective traits make each individual's perception, problem-solving, and preferences unique. This assertion leads to the second explanation of variance across groups, which refers to the "naturally occurring" differences that are apart of the notion of *individual psychology*. It is important to consider how each individual's unique personality disposition and subjective life experiences shape their style of cognition or thinking. Such a consideration would ask

the question, "Is risk-aversion a trait that, like other personality traits, is predetermined or biologically based?" Even without going so far as to assume qualities such as risk-aversion are biologically based, it does seem reasonable to believe that individuals may have integrated varying levels of this trait long before their first college class. On this assumption, we may then conclude that the acquired academic skill set of an individual may not be the determinant of choices under risk; rather, it may have been the naturally occurring risk preferences that a certain individual obtained before college that are completely unrelated to an acquired area of academic expertise. By this logic, we might question whether economics students are more risk-seeking toward gains because of their learned economics skill-set, or whether these particular risk-preferences are part of a larger, naturally occurring psychological disposition that in turn may determine the academic discipline a student pursues. To adequately address this question a longitudinal study would be required. By using a pretest/posttest design that tests the same broad concepts over time, an investigator could determine whether acquiring particular academic skill sets alters risk preferences. Without a longitudinal perspective to study the risk preferences of an individual before he or she has acquired a particular academic skill set, it is difficult to know for certain which is the larger source of internal variance. I sense that the reason economics students have unique risk-preferences is due to a combination of their inherent, pre-occurring risk tendencies *and* their learned economic skill set.

The subjects who answered the original Kahneman and Tversky questionnaire, from which they devised prospect theory, represented a "complete variety" of undergraduate students. These students presumably ranged from freshmen to seniors and were presumably drawn from a wide array of academic disciplines. Using these criteria,

it seems likely that the KT subjects differed from the CS subjects in two noteworthy ways. First, their study included subjects who were freshmen and sophomores. The present study limited the subject pool to juniors and seniors in attempt to control for the variable of age/expertise. Second, if their subject pool was truly "varied," as Kahneman asserts, their subjects probably included relatively more humanities majors and relatively less than one-third economics majors, and relatively less than one-third math/science majors, given the presumed composition of the student bodies at the tested universities. With this set of assumptions about the composition of their subject pool, it is understandable that the choices of the individuals in the humanities group of the current study closely mirrored most of the overall findings of the Kahneman and Tversky study. Likewise, without a disproportionally large number of economics majors or math/science majors in their subject pool, it seems reasonable that Kahneman and Tversky would have obtained such results. I cannot say with certainty that their conclusions would have been different had they, perhaps, tested only economics students, but the findings from this study indicate that doing so would likely have significantly altered their data and subsequent conclusions.

Behavioral studies such as Kahneman and Tversky's typically assert that their findings are indicative of the behavior of the public-at-large. This is a bold assertion because such a claim rests on the notion that their subject sample is representative of the greater population. The participants from both the KT study and the current study differ from the public-at-large in several consequential aspects. First, the subpopulations tested here and in the KT survey are relatively young in age, usually within the range of 18 to 22 years. Subjects in this age range are certainly legitimate consumers but many might lack the "real-world" consumption experiences of an older individual, who is more

representative in age of the broader population. Younger consumers, especially those of college age, typically lack financial responsibilities (ie. children, mortgage payments) that are commonplace among older consumers. A lack of financial responsibilities may make young consumers more willing to accept a risky prospect not because of their particular attitude towards risk but rather due to their *capacity to accept* risk.

Second, the testing populations are typically from highly accredited universities, and their mean IQ scores are likely significantly higher than individuals of the broader population. When intelligence is defined as the capacity to carry a cognitive load, it is reasonable to believe that a consumer's level of intelligence may be positively correlated to that consumer's ability to behave rationality and consistently.

Third, the testing subjects are drawn from western cultures that typically stress individual autonomy and an independent-view-of-the-self (Cross 1995). Other world cultures, for instance those in the East, promote group autonomy and an interdependent-view-of-the-self, which is "a way of defining oneself in terms of one's relationships to other people; recognizing that one's behavior is often determined by the thoughts, feelings, and actions of others" (Aronson 2004). An individual's perception of autonomy and group dependence might affect his willingness to engage in risk-seeking or risk-averse behavior. Consumers who view themselves from a group dependency perspective may be less likely to engage in risky behavior. Considering this aspect, the results from western studies of financial behavior may not be accurately generalized to represent the behavior of non-western peoples.

These three factors have not been adequately addressed in behavioral experiments. The testing populations of most behavioral psychology experiments are typically students similar to those tested here and to those tested by Kahneman and

Tversky. Variables such as age, intelligence, and cultural background should be integrated in future research before the results from behavioral surveys and experiments are extrapolated to explain the behavior of the public-at-large.

A final note addresses the topic of methodology and its relation to deriving results that represent truthful observations of reality. This study, and many others devoted to studying similar topics, discusses *what* researchers have learned about people, but not *how* they have learned it. Not every response that clashes with a rationality axiom is necessarily a judgmental error. The disagreement could arise from the subject's misunderstanding of the question or from the investigator's misunderstanding of the answer (Smith 1999). The results from the KT studies and the current study make the somewhat heroic assumption that these questionnaire responses are truly indicative of a consumer's actual behavior when confronted with real-world problems of risky choice. In this survey, there are several questions for which I believe it is very difficult to obtain truthfully predictive prospect choices. Particularly, prospects regarding very large amounts of money and very small probabilities may present scenarios that are difficult to assess truthfully when subjects process them only as a hypothetical question with no real consequences for the subject. Subjects are probably not purposefully deceptive, but some problems seem very difficult to extrapolate truthfully from a testing scenario to a "real-world" scenario. These questions of external validity are worth noting, but it seems unlikely that these concerns are significantly pervasive and forceful enough to corrupt the validity of these findings.

In an area of economics that is still developing, many chapters have now been written about decision theory and risky choice theory. The "accepted" position has shifted back and forth from the traditional to the radical and is currently positioned

somewhere between the camps of the advocates and opponents of alternate theories. A consensus has yet to be reached on these issues, and studies advancing the knowledge of this area are being completed each year that strengthen the argument for either side. This study shows many subjects exhibiting very irrational behavior, though it seems that certain types of individuals are more likely to exhibit such behavior than others. That said, it provides support for both the neoclassical model of risky choice and the alternate theory. To recapitulate the findings from this study, I draw from an analogy comparing the differing views of risky choice theory.

In an article reviewing behavioral literature, Daniel McFadden coined the terms "Chicago man" and "K-T man" referring to the dichotomous views of the consumer and his behaviors. The Chicago-man refers to the neoclassical view of the consumer, who is a maximizer of all things and unfailingly rational in the sense of traditional economic theory. The K-T man refers to the alternate view (as Kahneman and Tversky have suggested) that is based on psychological tendencies and cognitive anomalies and downplays strict maximization. While economics once subscribed to the notion that we are all Chicago men (or women), behavioral decision theory has garnered a growing mountain of evidence that suggests everything from his non-existence to a severe restriction of his maximum range. McFadden states that the "Chicago man is an endangered species." Evidence of past decades supports the concept of the K-T man and corresponding models of behavior. Based on this evidence, it is simple and convenient to declare the K-T man as the prevalent choice. I politely object to McFadden's statement and conclude that it is perhaps reasonable that the Chicago man is simply a rarer breed of decision-maker than was once believed. Any declaration that all consumers are Chicago men who obey strict rules of preference rationality would be in the face of significant

contradictory evidence. However, it might not be unreasonable to conclude, based on the evidence from this study, that on the spectrum of decision-making, some consumers gravitate towards the K-T pole, but others may still hover in the direction of the Chicago-man model. Psychologists commonly recognize that individuals often lie within a broad range when assessing a particular trait or tendency, opposed to binary categorization. This may be a fitting explanation for the question at hand. Economists recognize the spectrum of human qualities, but often de-emphasize these differences in their microeconomic models of behavior. Alternate economic models should acknowledge the array of differences in economic agents, where such differences promote varying approaches to tasks such as decision-making and risky-choice behavior. Recognizing the "adaptive flaws" that litter the landscape of human cognition is essential to adopt a more practical and descriptive approach to rationality and the role of this concept in economics. Psychology has made noteworthy contributions here, but might do well to entertain the idea that certain individuals may be predictably less prone to the irrationalities and cognitive limitations that it has demonstrated do, in fact, exist in many individuals. Ultimately, a multi-theory approach, respectful of both the Chicago-man *and* K-T man, may be the most appropriate explanation for our behavior, be they perfectly rational and regular or completely illogical and inconsistent.

APPENDIX:

t-values of differences in proportions between testing groups
* indicates that the differences are significant at the 0.05 level

Problem		**Science**	**Liberal Arts**	**Economics**
1	Science		-0.12	-0.38
	Liberal Arts	-0.12		-0.49
	Economics	-0.38	-0.49	
2	Science		1.14	-0.07
	Liberal Arts	1.14		1.06
	Economics	-0.07	1.06	
3	Science		-0.04	2.95*
	Liberal Arts	-0.04		2.89*
	Economics	2.95*	2.89*	
4	Science		1.65	0.86
	Liberal Arts	1.65		2.53*
	Economics	0.86	2.53*	
5	Science		1.44	-0.39
	Liberal Arts	1.44		1.04
	Economics	-0.39	1.04	
6	Science		1.14	-0.35
	Liberal Arts	1.14		0.78
	Economics	-0.35	0.78	
7	Science		0.49	-0.88
	Liberal Arts	0.49		-0.39
	Economics	-0.88	-0.39	
8	Science		-0.07	-0.86
	Liberal Arts	-0.07		-0.92
	Economics	-0.86	-0.92	
3*	Science		-0.16	-1.09
	Liberal Arts	-0.16		-1.24
	Economics	-1.09	-1.24	
3*	Science		-0.84	-0.95
	Liberal Arts	-0.84		-1.79*
	Economics	-0.95	-1.79*	

9	Science		-1.65*	0.37
	Liberal Arts	-1.65*		-1.26
	Economics	0.37	-1.26	
10	Science		-0.34	-1.40
	Liberal Arts	-0.34		-1.74*
	Economics	-1.40	-1.74*	
11	Science		-1.21	3.07*
	Liberal Arts	-1.21		1.77
	Economics	3.07*	1.77	
12	Science		-0.63	-0.61
	Liberal Arts	-0.63		-1.23
	Economics	-0.61	-1.23	
13	Science		-0.41	-0.34
	Liberal Arts	-0.41		-0.75
	Economics	-0.34	-0.75	
14	Science		0.64	-0.14
	Liberal Arts	0.64		-0.50
	Economics	-0.14	-0.50	
15	Science		-0.41	1.64
	Liberal Arts	-0.41		1.61
	Economics	1.64	1.61	

BIBLIOGRAPHY:

Allais, M. (1953) Le compartement de l'homme rationnel devant le risqué, critique des postulats et axioms de l'ecole Americaine. *Econometrica,* 21, 503-546.

Anand, P. (1993). *Foundations of Rational Choice Under Risk.* Oxford: Clarendon Press.

Anslie, G. (1982). Behond microeconomics: Conflict among interests in a multiple self as a determinant of value. In J. Elster (ed.), *The Multiple Self.* Cambridge, UK: Cambridge University Press.

Aronson, E., Akert, R., Wilson, T. (2004). *Social Psychology*. Upper Saddle River,NJ: Pearson Prentice Hall.

Baron, J. (2000) *Thinking and Deciding*. Cambridge: Cambridge University Press.

Camerer, C.F. (1998). Behavioral economics ad organizational decision-making. In J.J. Halpern and R.N. Stern, eds., *Debating rationality: Nonrational aspects of organizational decision making.*

Cross, S.E. (1995). Self-construals, coping, and stress in cross-cultural adaptation. *Journal of Cross-Cultural Psychology,* 26, 673-697.

Fox, C. & Tversky, A. (1998) A belief-based account of decision under uncertainty, *Management Science,* 44:7.

Friedman, M., & Savage, L.J. (1948). The utility analysis of choices involving risks," *Journal of Political Economy*, 56*, 279-304.*

Halpern, J. & Stern, R. (1998) *Debating Rationality*. Ithica, NY.: Cornell University Press.

Kahneman, D., Knetsch, J., & Thaler, R.H. (1991). The endowment effect, loss aversion, and the status quo bias. *Journal of Economic Perspectives, 5,* 193-206.

Kahneman, D., & Tversky, A. (1979). Prospect theory, an analysis of decision-making under risk, *Econometrica,* 47, 263-292.

Kahneman, D., & Tversky, A. (1984). Choices, values, and frames, *American Psychologist*, 39:4, 341-350.

Kahneman, D., & Tversky, A. (1992). Advances in prospect theory, *Journal of Risk and Uncertainty*, 5, 297-323.

List, J. (2003). Neoclassical theory versus prospect theory: Evidence from the marketplace. Forthcoming. National Bureau of Economic Research.

List, J. (Feb 2003). Does market experience eliminate market anomalies? *Quarterly Journal of Economics,* 41-63.

McFadden, D. (1999). Rationality for economists? *Journal of Risk and Uncertainty*, 19*,* 73-105.

Raaij, W.F. van (1981). Economic psychology, *Journal of Economic Psychology,* 1:1, 1-13.

Rabin, M. (1998). Psychology and economics, *Journal of Economic Literature,* 36:1, 11-46.

Savage, L.J. (1954) *The Foundations of Statistics*. New York: Wiley.

Simon, H. (1957) *Models of Man*. New York: Wiley.

Smith, V. (2003). Constructivist and ecological rationality, *The American Economic Review,* 93:3, 465-508.

Surowiecki, James. (2001) Boom and Gloom, *The New Yorker*, Nov. 11, 2001.

Thaler, R. (1980). Towards a positive theory of consumer choice, *Journal of Economic Behavior, 1:1,* 39-60.

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases, Science, 1124-1131.

Tversky, A. & Kahneman, D. (1981). The framing of decisions and the psychology of choice, *Science, 211,* 453-458.

von Neumann, J., & Morgenstern, O. (1944) *Theory of games and economic behavior.* Princeton: Princeton University Press.