Core Knowledge Area Module II:
Principles of Human Development
Decision Theory

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ABSTRACT

Breadth

Many theories describing decision making have been postulated over the last 100 years in hopes of accurately predicting choices. In this essay, Von Neumann and Morgenstern's expected utility theory, Kahneman and Tversky's prospect theory, and Bell and Loomes and Sugden's regret theory are examined, compared, contrasted, synthesized, and integrated in order to model the decisions associated with the television game show "Deal or No Deal." These decisions are based on the axioms and concepts of expected utility theory, yet are further defined by the inclusion of regret in the model. Prospect theory, however, does not contribute any additional information to the model since Deal or No Deal players are generally risk seeking rather than risk averse.

ABSTRACT

Depth

Just as this world is made up of many different people, there are also just as many different ways to make decisions. Thus, in this essay, several recent studies regarding new or modified decision theories were examined for their applicability to decisions made during the game show Deal or No Deal. For example, risk in terms of loss aversion was evaluated with respect to the endowment effect and utility elicitation. In addition, risk was also described with respect to its potential harm or benefit. Simple heuristics such the priority heuristic, affect heuristic, and lemon avoidance heuristic were also evaluated in this essay. New theories such as temporal motivational theory and the theory of intrapersonal games were examined as well.

ABSTRACT

Application

Data from the first two seasons of the American version of the game show Deal or No Deal were studied in order to characterize the decision making process. The results showed that although the game promoted risk seeking behavior, females were more risk averse than males. However, the female player's aversion to risk led to significantly higher winnings. In addition, the majority of players opted to take the Banker's offer by round nine. Only 13 risk seeking players remained in the game until the final round and won significantly less than the other players. Similar trends were found when the current study was compared to the Australian and United Kingdom versions of the game.

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Introduction

Millions of decisions are made everyday by governments, organizations, corporations, groups, and individuals. Decisions are made because choices exist and the decision maker must act. But decision making is often not as simple as choosing between, for example, alternatives A, B, and C. Often the decision is a compound one which must be made in stages (e.g., first choose between A and B and then based on that decision, choose between C and D, etc.). In addition, there are often circumstances surrounding the decision that influence the decision maker's preferences. There can also be pre-conceived biases that sway the decision making process. The amount and availability of information can also affect decisions. Even the decision maker's willingness to make the decision can affect the outcome. In other words, a single decision can be affected by many factors.

The field of Decision Theory attempts to psychologically, sociologically, economically, or mathematically explain the process behind decision making with the goal of being able to predict the decision maker's actions and choices. In reality, this field should perhaps be called "Decision Theories" because just as there are multiple factors affecting decisions, there are multiple theories to explain the decision making process under various circumstances (such as under risky or riskless conditions). In this essay, three of these theories will be critically examined, integrated, and synthesized in an attempt to describe the decision making process during the American version of the television game show "Deal or No Deal." These three theories are utility theory (including expected utility theory), prospect theory, and regret theory.

The Decision Models

Utility theory was first proposed by Danielle Bernoulli in 1738 while striving to solve a perplexing problem known as the St. Petersburg Paradox which was proposed years earlier by his cousin Nicholas Bernoulli (Bernoulli, 1738/1954; Plous, 1993). Many years later, this theory was refined by John Von Neumann and Oskar Morgenstern (Von Neumann & Morgenstern, 1953; Plous, 1993) to explain utility theory from a normative point of view. The result was an extension of utility theory referred to as expected utility theory. Thus, the writings of these theorists will be critically examined in order to consider utility theory and expected utility theory as possible models to explain the player's decisions during the game show Deal or No Deal.

Although widely popular, expected utility theory is not a "one-size-fits-all" model that explains all decision making behavior. In addition, not every situation surrounding the decision will meet all of the assumptions for this model. Thus, many theories have been presented in recent years as alternatives to expected utility theory (Plous, 1993). For example, perhaps one of the most prominent of alternative theories of recent times is prospect theory, first introduced by theorists Daniel Kahneman and Amos Tversky (1979). Prospect theory proposed that when faced with a decision presented in terms of a gain, people were risk averse (i.e., unwilling to take the risk) while they were risk seeking when the decision was presented in terms of a loss (Plous, 1993). Another alternative theory is regret theory presented by theorists David Bell (1982; 1985) and Graham Loomes and Robert Sugden (1982; 2001) who took into consideration decisions that were based on what could have happened if a different decision had been made (i.e., decisions based on regret or elation). Both of these decision theories will be examined with respect to the television game show Deal or No Deal. Thus, it is important to understand not only the rules of the game, but how and when players are presented with decisions so that their decision making behavior can be modeled.

Deal or No Deal Strategy

The television game show Deal or No Deal was created in Holland in 2001 (History of Deal and No Deal, 2007). Deemed an immediate success, similar versions of the game show have been created in various countries around the world including America. The American version of Deal or No Deal premiered on December 19, 2005 (Deal or No Deal: About, n.d.).Since the rules of the game can vary slightly from country to country depending on their preferences, only the rules of the American version of this game show will be considered in this essay.

In this game, 26 briefcases contain various amounts of money ranging from $0.01 to $1,000,000 (see Table 1). To begin the game, the player randomly chooses one case. This case is held unopened until the end of the game. Hoping to have chosen the case with $1,000,000, the player continues the game by randomly choosing cases to be opened in each round according to the schedule: six cases are opened in round one, five in round two, four in round three, three in round four, two in round five, and one case in each of the remaining four rounds. After each round, once the case amount(s) have been revealed, an anonymous “Banker” makes an offer that the player must either choose to keep, thus ending the game, or refuse and continue the game. If the player continues to the end of round nine, their originally chosen case is opened to reveal their prize.

Table 1. Prize Amounts Offered in Deal or No Deal	
$ 0.01	$ 1,000.00
1.00	5,000.00
5.00	10,000.00
10.00	25,000.00
25.00	50,000.00
50.00	75,000.00
75.00	100,000.00
100.00	200,000.00
200.00	300,000.00
300.00	400,000.00
400.00	500,000.00
500.00	750,000.00
750.00	1,000,000.00

The Banker's offer varies depending on the amount of money still in play. After choosing the first case, the player's strategy during the game is to "walk away" with as much money as possible either through successful elimination of all the low value cases or by accepting a high offer from the Banker. The goal of the Banker is to make the player leave the game with as little money as possible. To that end, the Banker remains hidden from view in order to seem menacing and intimidates the player by making fun of him or her. In some games, the Banker tries to entice the player to take the offer and leave the game by providing incentives (e.g., a specially designed car or season football tickets for the player's favorite team).

Note that a single player alone makes the decision to either take the Banker's offer (a sure thing) or to continue to the next round (a risk). However, after round two, the player may enlist the opinions of three or four previously-selected friends and/or family members (i.e., supporters). In addition, the game show audience actively voices their opinions while the player contemplates the decision. The Banker's intimidation efforts often add to these distractions during the decision making process. Although these psychological distractions may contribute to the player's ultimate decision, this effect will not be addressed in this essay. This essay will focus on describing the decision-making process in Deal or No Deal in terms of risk and based on the decision theories previously described.

The Decision Making Process

"Economic Man" and Rationality

The study of any theory typically begins with a statement of the underlying assumptions. The main assumption for normative decision models is that of rationality (to be explained further below). Edwards (1954) generally referred to the rational decision maker (whether male or female) as "economic man" (p. 381). In addition to the assumption of rationality, Edwards described economic man as being completely aware of all possible alternatives and outcomes (i.e., completely informed). Simon (1955) further defined this aspect of economic man as having clear and complete knowledge of his or her environment, including all information relevant to the decision at hand. The third assumption of economic man described by Edwards is that the available alternatives and prices are continuous, infinitely divisible functions which allow economic man to be infinitely sensitive. For the purpose of this essay, "economic man" will be used to characterize the decision maker who meets all of these assumptions regardless of gender.

According to Edwards (1954), there are two properties that describe rational decision making. The first property is that economic man can weakly order his or her preferences among the alternatives. Edwards described this as the decision maker's ability to choose based on preferences. In other words, given two alternatives, economic man should be able to prefer one alternative over the other or remain indifferent. In addition, these preferences must be transitive in that if economic man chooses alternative 1 over alternative 2 and alternative 2 over alternative 3, then it follows that he or she must also choose alternative 1 over alternative 3. The second property of rationality describes the general purpose of decision making—to choose so as to maximize something of importance to the decision maker. With this goal in mind, economic man will always choose the best alternative.

Characterizing the Deal or No Deal game show player in terms of economic man, it is obvious that the player meets all of the assumptions. Not only is the player aware of all of the alternatives (i.e., to deal or not to deal) and outcomes (i.e., if they take the deal, they accept the banker's offer and end the game or if they don't take the deal, they continue to play the game), but the player is also rational. In the process of playing the game, the rational player develops preferences between the two alternatives and will choose the alternative that he or she believes will maximize their winnings. Even with this ability to be rational and the desire to maximize winnings, the player's choice may result in a loss. This is because there is risk involved in this decision making process that may influence the outcome. One other assumption concerning rationality needs to be stated here. That is, the players are equivalent in terms of their rational decision making capacity and risk aversion. In other words, if two players are presented with the exact same information and both have the same background, perceptions, etc., they would both make the same rational decision (i.e., one is not “smarter” than the other).

Risky and Riskless Decisions

Decision making can be classified as being risky or riskless. Edwards (1954) described both risky and riskless decisions in terms of the rational desire to maximize something. For Edwards, a riskless decision resulted in the maximization of utility while a risky decision resulted in maximizing expected utility. In terms of today’s language, a riskless decision is considered to be “decision making under uncertainty” because the probability associated with each utility or outcome is unknown (i.e., uncertain). Thus, this decision is based simply on the greatest utility or outcome. Alternatively, a risky decision is considered to be “decision making under risk” since the probability (i.e., likelihood or risk) associated with each utility is known. Edwards (1954, p. 391) referred to this risky proposition as a first-order risk and gave the general form of this expected value as

$$EV = \sum_{i=1}^{n} p_i \$_i$$

where

$n =$ number of outcomes Eq 1.

$p =$ probability associated with the i^{th} outcome and $\sum_{i=1}^{n} p_i = 1$

$\$ =$ monetary outcome

Kahneman and Tversky (1984) provided examples of both risky and riskless decisions. According to Kahneman and Tversky, an example of a risky decision would be a gamble in which the monetary outcomes are associated with specific probabilities. In this case, the probabilities in a risky gamble attempt to eliminate the uncertainty associated with the specific outcomes when trying to choose based on unknown future events. When the future is uncertain but the probabilities associated with the outcomes are not available, then the decision is considered riskless (i.e., without probabilities) and is simply based on preferences (Edwards & Tversky, 1967). An example of a riskless decision would be determining which good or service is acceptable with respect to the associated exchange of money or labor (Kahneman & Tversky, 1984).

Risky Decisions in Deal or No Deal

Each decision in the game show Deal or No Deal is an example of a risky gamble. For each round, there are probabilities associated with opening the specified number of cases for that round. For example, before the first round the player must choose one of the 26 cases with the goal of selecting the $1,000,000 prize. At this point in the game, the probability of choosing the case with $1,000,000 is simply $\frac{1}{26}$. Once this first chosen but unopened case is removed from play, the player must then open a specified number of cases during each round. Although the selection process is random, the player's goal is to choose cases with the lowest dollar amount inside in order to obtain the maximum offer by the banker. Within each round, the probability of choosing c lowest value cases can be calculated as

$$\prod_{i=0}^{c-1}\left(\frac{1}{n-i}\right) \qquad \text{Eq 2.}$$

where c is the number of cases to be opened in that round, and n is the remaining number of unopened cases in play for that specific round. For example, during round two, there are 19 cases remaining and the player must open five. The probability that the player chooses each of the five lowest value cases remaining in play is:

$$\prod_{i=0}^{5-1}\left(\frac{1}{19-i}\right)=\frac{1}{19}\cdot\frac{1}{18}\cdot\frac{1}{17}\cdot\frac{1}{16}\cdot\frac{1}{15}=7.17\times10^{-9} \qquad \text{Eq 3.}$$

As the game continues and the number of unopened cases decreases, the probability of opening a case with a high value increases, thus decreasing the chances of winning a lot of money. These observations will be discussed in more detail in the Application component of this essay.

In order to compute the expected value of a risky decision, Edwards (1954) considered the outcome in terms of its monetary value. However, Bernoulli (1738/1954) believed that the value of an outcome could not be adequately represented by the monetary value alone. This is because the monetary value is a fixed value that does not change with respect to the outcome. However, the "utility" or perceived benefit of that outcome and its associated monetary value will change from person to person due to that person's frame of reference. Thus, Bernoulli introduced the idea of utility with respect to decision making.

Utility Theory

Daniel Bernoulli

Utility was first introduced by Daniel Bernoulli (1738/1954) in an attempt to resolve a mathematical challenge (referred to as the St. Petersburg Paradox) presented years earlier by his cousin Nicholas Bernoulli (Savage, 1967; Plous, 1993). Nicholas Bernoulli posed the following problem (in terms of today's currency; Plous, 1993): an unbiased coin is tossed until it lands on "tails." If tails appears on the first toss, the player is paid $2.00, if it appears on the second toss the player is paid $4.00, if it appears on the third toss, $8.00, and so on. In essence, the payoff is $\$2^n$ where n is the number of tosses until a tail is obtained. Nicholas Bernoulli was interested in determining how much money a person would be willing to pay to play this game. If the player paid a small amount to play and a tail was not obtained until after many tosses, then that player would obviously benefit greatly. However, if the player paid a lot to play and a tail was achieved after only a few tosses, then that player would not benefit from the game. Assuming independence and constant probabilities, if the probability of obtaining a tail is $P(T) = \frac{1}{2}$, then the expected gain (or expected value) of playing this game is

$$\text{EV} = \left(\frac{1}{2}\right)^n 2^n \qquad \text{Eq 4.}$$

where n = number of tosses

which results in an infinite gain (Schoemaker, 1982, p. 531; Plous, 1993, p. 79). Thus the paradox—it is difficult to place a dollar amount on how much a person would be willing to pay when the potential gain is infinite.

Daniel Bernoulli (1738/1954) determined that there was more involved in a gamble (i.e., risky decision) than just the consideration of the monetary gain (which is constant regardless of the player). Indeed, Bernoulli believed that a person's current financial frame of reference would greatly affect their decision in a gamble. In other words, a player with very little financial resources would consider a small monetary gain to be large whereas someone who is more financially well-off would consider the same small gain to be inconsequential. The value or benefit of the gain is assessed by the player relative to their current financial status. As a result, Daniel Bernoulli suggested that the decision making process behind risky gambles was made in terms of the expected "utility" of the outcome (Kahneman & Tversky, 1984). Thus, the decision of how much to pay to play Nicholas Bernoulli's game is influenced not only by the potential monetary gain, but also by the perceived benefit or utility of that gain which would eventually decrease rather than increase infinitely as the expected value indicates.

Assuming that a person's wealth continuously increases in very small incremental amounts, utility can be described as being inversely proportional to the quantity of goods (i.e., both essential and non-essential commodities) already owned (Bernoulli, 1738/1954, p. 25). In other words, the more money or wealth that a person has, the less useful or valuable small incremental increases in monetary value will be to that person. Thus as wealth increases incrementally, utility decreases. The function describing this expected utility is logarithmic (Schoemaker, 1982) and results in a concave function of the utility of money as illustrated in Figure 1 (Kahneman & Tversky, 1984; Plous, 1993).

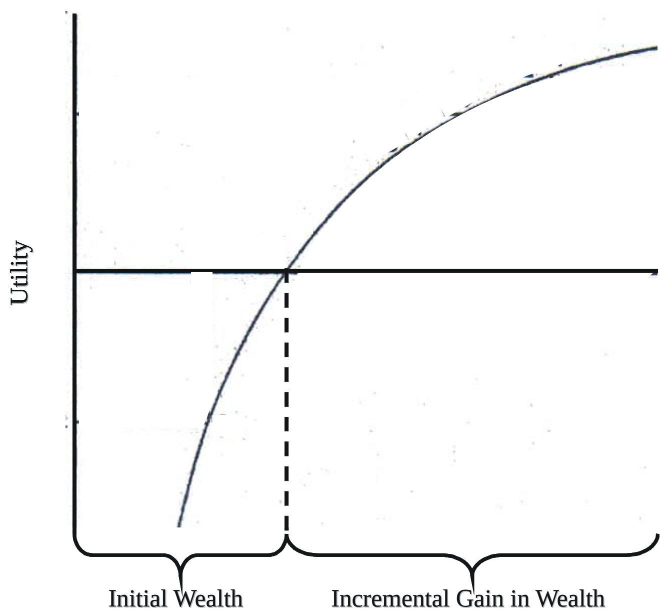

Figure 1. Bernoulli's Concave Utility Function (Adapted from Bernoulli, 1738/1954 and Plous, 1993).

Decision making based on utility is evident on the television game show Deal or No Deal. Each player makes the decision to take the banker's offer or not based on their current monetary frame of reference. The show's host Howie Mandel often states that the game provides a life-changing experience since most players come to the game with specific needs (e.g., they need to buy a house, they are jobless, etc.). In other words, every player is in need of money. The potential to win a million dollars would provide for that need and therefore change the player's life. Thus for these players, monetary utility is very relevant. The player seeks to win the million dollars, but often settles for what they deem to be acceptable according to their (subjective) utility measure.

The question remains as to how utility is measured. Bernoulli did not provide a direct way to measure this subjective value that is dependent on the decision maker's current frame of reference (Schoemaker, 1982). In an attempt to further define this concept, Bernoulli (1738/1954) determined the mean utility or "moral expectation" (p. 24) to be a weighted average of the utility of each profit expectation where the weights are the frequencies of occurrence. The decision maker's goal is to maximize the mean or expected utility (Edwards, 1954). Marginal utility, then, is measured as the incremental change in utility with a miniscule change in commodity possessed (Edwards, 1954) which decreases as wealth increases. Thus the concave function of the utility of money seen in Figure 1 above reflects this trend which Savage (1967) referred to as the "law of diminishing marginal utility" (p. 99).

Utility as Bernoulli described it had limitations. It could not adequately describe actual decision making behavior. Under Bernoulli's moral expectation model, utility was a subjective measure of "pleasure" and "pain" in which pleasure was represented as a positive utility and pain as a negative utility (Edwards, 1954, p. 382). Although utility can be explained and understood in this way, it is difficult to formulate a numerical value to represent this utility. In an effort to make this clearer and more applicable to real-life situations, John Von Neumann and Oskar Morgenstern (1953) addressed Bernoulli's utility in terms of both the subjective value and objective probabilities to describe a model of expected utility maximization (Edwards, 1967) or expected utility theory.

Expected Utility Theory as an Extension of Utility Theory

John Von Neumann and Oskar Morgenstern

Approximately 200 years after Daniel Bernoulli presented his concept of utility, John Von Neumann and Oskar Morgenstern revised it with respect to expected utility in order to describe current economic behavior (Von Neumann & Morgenstern, 1953). Their resulting analysis was considered ground-breaking work in the area of game theory and renewed interest in this aspect of decision theory (Schoemaker, 1982). Von Neumann and Morgenstern extended Bernoulli's moral expectation theory to include a series of axioms (i.e., assumptions) underlying rational decision making (Plous, 1993) and described the numerical concept of utility, resulting in expected utility theory. In laying these ground rules, so to speak, Von Neumann and Morgenstern built a foundation upon which later decision theorists could extrapolate their own theories.

Von Neumann and Morgenstern (1953, pp. 26-27, 617) used the following notation in presenting these axioms:

$U =$ a system of abstract utilities (numbers up to a linear transformation)
$u, v, w =$ utilities
$\alpha, \beta, \gamma, \ . \ . \ . \ \rho, \sigma =$ numbers
$u > v =$ natural preference relation; u preferred over v
$\rho > \sigma =$ numerical preference relation; ρ preferred over σ

Axiom 1: Ordering. When two alternatives are compared, the rational decision maker should prefer one alternative over the other or remain indifferent (Plous, 1993). Von Neumann and Morgenstern (1953) referred to this as “completeness of the system of individual preferences” (p. 27) and stated it mathematically: For any two utility functions *u, v* only one of the following relations will hold $u = v$ (i.e., indifference), $u > v$, or $u < v$. Edwards (1954) referred to this axiom as the first requirement for weak ordering of economic man (i.e., the rational decision maker). This assumption is met in the game show Deal or No Deal decisions. The players are able to effectively order the alternatives (i.e., take the deal or not) according to their preferences.

Axiom 2: Transitivity. Given the preference relationships $u > v$ and $v > w$, then it is assumed that $u > w$ (Von Neumann & Morgenstern, 1953). This is Edwards’ (1954) second requirement for weak ordering of economic man. There is no reason to doubt this assumption in the game show Deal or No Deal decision making.

Axiom 3: Continuity. This assumption states that when presented with the choice between a gamble resulting in either a good or bad outcome, and a sure outcome somewhere in the middle, the rational decision maker will prefer the gamble if the chance of obtaining the good outcome in the gamble is high enough (Plous, 1993). Thus if $u < w < v$, then there exists an α such that $\alpha u + (1 - \alpha) v < w$ (Von Neumann & Morgenstern, 1953, p. 26). Interestingly, this axiom succinctly describes decision making during the game of Deal or No Deal. When the player is presented with the option to take the deal (a sure gain somewhere in between the highest and lowest dollar amounts left in play) or to continue playing, the player’s decision is typically based on the chances of obtaining the highest amount left in play (i.e., the good outcome in the gamble). If the probability of that gamble is high enough, then the player typically refuses the deal and continues the game. If the probability of that gamble is not high enough, then the player should take the deal (i.e., the sure gain). However, the player may not act rationally due to influence from the audience and the player's supporters and the desire to go for "all or nothing" during the gamble.

Axiom 4: Combining. This assumption states that the order in which the utilities of a combination are given is irrelevant. Thus, $\alpha u+(1-\alpha)v=(1-\alpha)v+\alpha u$ (Von Neumann & Morgenstern, 1953, p. 26). Again, there is no reason to doubt this assumption for the Deal or No Deal game decisions.

Axiom 5: Invariance. This assumption concerns the decision maker's preference for presentation of the alternatives. In other words, how the alternatives are presented (i.e., whether in a one-stage or two-stage gamble resulting in the same outcome either way) should be irrelevant to the rational decision maker (Von Neumann & Morgenstern, 1953; Plous, 1993). This is presented mathematically as $\alpha\left(\beta u+(1-\beta)v\right)+(1-\alpha)=\gamma u+(1-\gamma)v$, where $\gamma=\alpha\beta$ (Von Neumann & Morgenstern, 1953, p. 26). This assumption also is not challenged concerning decisions made during the Deal or No Deal game.

Although the Von Neumann and Morgenstern (1953) axioms were supposed to make the actual measurement of utility easier, Jensen (1967) disagreed, stating that the utility function was still extremely difficult to determine. In presenting his arguments, Jensen described several objections to the axioms. Jensen was first concerned that although a preference relation between two alternatives could be interpreted (i.e., axiom 1), a corresponding interpretation of the indifference relationship between the alternatives could not. In other words, preference can be defined based on observed choices that the decision maker makes. However, indifference cannot be defined based on observable choices. Jensen concluded that in order for this axiom to hold, the preference relations would have to be presented stochastically.

Jensen's (1967) second concern centered on the number of choices available for a given decision. Von Neumann and Morgenstern's axioms (1953) described decision making in terms of choosing between two alternatives. However, Jensen believed that an infinite number of alternatives existed for any one decision and all of those alternatives influenced preference. This would make it very difficult to assign a numerical preference value to the utility. Jensen also felt that the axioms focused on single, one-time-only decisions whereas in real life, decisions are often made in sequence over time, based on previous choices. Of final concern to Jensen was whether the decision maker was completely informed of the effects of a decision before making it. This would also affect the preference relationships.

With the Von Neumann and Morgenstern (1953) axioms in place however, the objections and challenges that arose resulted in several new theories concerning expected utility. Schoemaker (1982) reported nine variants on expected utility including subjective expected utility, weighted monetary value, certainty equivalence theory, subjectively weighted utility, and prospect theory. Perhaps the most famous variant is prospect theory first presented by Kahneman and Tversky (1979). Preference in a gamble is a concept that is governed not only by the strength of the preference, but also by the decision maker's attitude toward risk (Schoemaker, 1982). It is this consideration of the attitude toward risk (i.e., risk seeking or risk averse) that separates Kahneman and Tversky from Von Neumann and Morgenstern in their views of expected utility.

Prospect Theory as an Alternative to Utility Theory

Daniel Kahneman and Amos Tversky

Prospect theory was first introduced by Daniel Kahneman and Amos Tversky in 1979 as an alternative to utility theory and its extension, expected utility theory. Through a series of empirical experiments, Kahneman and Tversky observed that the individual choices made concerning gambles or prospects often violated many of the axioms that were proposed by Von Neumann and Morgenstern (1953). For example, by observing the choices made when presenting the following alternatives to 95 individuals, Kahneman and Tversky (1979) showed that a violation of expected utility theory occurred (p. 266):

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

$B:(3,000)$

Here, alternative A represents a risky prospect of obtaining 4,000 with probability 0.80 and 0 with probability 0.20 (resulting in an expected value of $(4,000\times.8)+(0\times.20)=3,200$), while alternative B represents a riskless or certain prospect of receiving 3,000 with probability 1.0 (resulting in an expected value of $(3,000\times1)=3,000$). Based on Von Neumann and Morgenstern's (1953) normative expected utility theory, the respondents should have chosen alternative A because the expected utility was higher. However, Kahneman and Tversky (1979) found that 80% of the respondents chose alternative B, a sure gain of 3,000, over the risky prospect. This indicated that the respondents were risk averse (i.e., unwilling to take a risk) when the alternatives were presented in terms of a gain. Plous (1993) attributed the difference in responses to the respondent's point of view which Levy (1997) referred to as the reference point or frame. In other words, under expected utility theory, the decision is based on the individual respondent's view of the utility of the alternative regardless of the reference point, whereas in prospect theory, the decision is based on the value of the alternative in terms of a gain or loss with respect to the individual respondent's reference point (usually current wealth; Plous, 1993; Levy, 1997).

Since the above decision involved both risky and riskless alternatives, Kahneman and Tversky (1979) repeated the experiment using only risky choices. Kahneman and Tversky presented the following choices to the same 95 individuals (p. 266):

$C:(4,000,.20)$

$D:(3,000,.25)$

Here, alternative C represents a gamble with expected value $\left(4,000\times.20\right)+\left(0\times.80\right)=800$ while alternative D represents a gamble with expected value $\left(3,000\times.25\right)+\left(0\times.75\right)=750$. This time, 65% of the respondents chose the gamble with the highest expected value or utility—alternative C—as predicted by expected utility theory. However, Kahneman and Tversky (1979) still considered this response to be a violation of expected utility theory because of the "certainty effect" (p. 265). Under the certainty effect, respondents have a tendency to apply too much weight to outcomes that are considered certain (such as alternative B) as compared to probable outcomes (such as alternative A).

In the case of the second risky decision set presented above, Kahneman and Tversky believed that the certainty effect represented a violation of the "substitution" axiom (most likely Von Neumann and Morgenstern's invariance axiom). For example, alternative C can be substituted by $(A,.25)$ (i.e., $\left[\left(4,000\times.8\right)+\left(0\times.20\right)\right]\times.25=800$) and alternative D by $(B,.25)$

(i.e., $\left[\left(3,000\times 1\right)\right]\times .25 = 750$), thus having the same expected values as alternatives C and D, respectively. Based on this and according to the substitution axiom, if the respondents chose alternative B in the first decision, they should have also chosen alternative D in the second decision. Since this was not the case (i.e., the respondents chose B in the first decision and C in the second), a violation of expected utility theory occurred in the second decision set.

Based on these and other observations, Kahneman and Tversky (1979) showed that expected utility theory did not adequately describe the decision making process associated with risky decisions. As a result, Kahneman and Tversky presented an alternative decision theory—prospect theory. A theory of how individuals make decisions under conditions of risk, prospect theory categorizes the decision making process in terms of gains (a positive prospect) and losses (a negative prospect) (Kahneman & Tversky, 1979; Levy, 1997). When considering choices presented in terms of gains, Kahneman and Tversky showed that respondents were not willing to choose the risky alternative (i.e., they were risk averse) and preferred instead the certain alternative. They also showed that the opposite was true when decisions were made based on losses. In other words, respondents were risk seeking (i.e., willing to take a risk) rather than risk averse when facing negative prospects. Kahneman and Tversky referred to this as the "reflection effect" (p. 268) because the decision sets in terms of gains and losses were mirror images. For example, consider the decision set with alternatives A and B which was presented earlier and whose mirror image in terms of losses is referred to as A' and B' (p. 268):

$A': (-4,000, .80)$

$B': (-3,000)$

In this case, 92% of respondents preferred the 20% risk of losing nothing and 80% risk of losing 4,000 rather than lose 3,000 with certainty (Kahneman & Tversky, 1979, p. 268). Thus, the reflection effect describes this risk seeking preference that is contrary to or a mirror image of the risk averse preference that occurred when choices were presented in terms of gains. The mirror image of alternatives C and D (i.e., C' and D') exhibited this risk seeking preference as well. Kahneman and Tversky believed that this preference for risk in the negative domain also violated expected utility theory through the certainty effect.

Which alternative the respondent chooses depends on his or her frame of reference with respect to their current level of wealth (i.e., current asset position represented by w; Kahneman & Tversky, 1979; Plous, 1993). Levy (1997) referred to prospect theory's dependency on the reference point as its central theme or assumption. As a result, it is both the magnitude change in wealth and the current asset position w that affects the value function of prospect theory. Kahneman and Tversky graphically showed that this value function was concave for changes in wealth in the positive domain (similar to the utility curve shown in Figure 1; Von Neumann and Morgenstern, 1953) and convex for changes in the negative domain. In addition, regardless of whether the change was in the form of a gain or loss, the marginal value tended to decrease as the magnitude of the change increased due to the psychological perception of the value of money (Kahneman & Tversky, 1979). For example, the marginal increase in the value function associated with a gain from 100 to 200 is greater than the marginal increase associated with a gain from 1100 to 1200 (Kahneman & Tversky, 1979, p.278). This "S-shaped" value function is presented in Figure 2 below (Kahneman & Tversky, 1979; Plous, 1993).

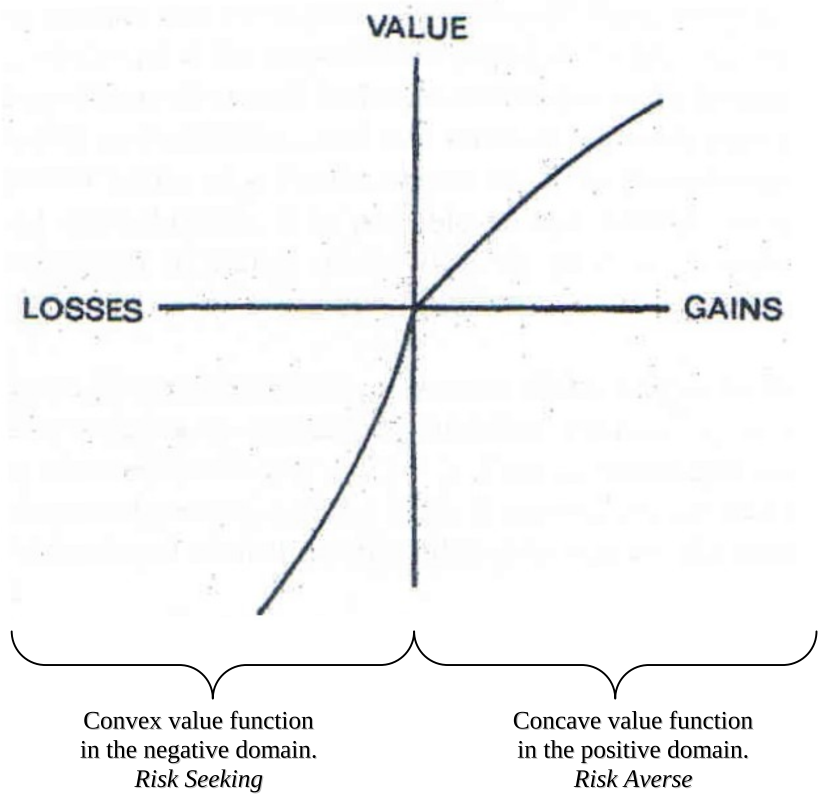

Figure 2. Prospect Theory’s Hypothetical Value Function (Adapted from Kahneman and Tversky, 1979, p. 279)

Note that the convex curve associated with losses indicates the respondent’s preference for risk seeking while the concave curve associated with gains indicates the respondent’s preference for risk aversion during the decision making process. Note also that the value function associated with losses (the convex curve) changes more rapidly than the value function associated with gains (the concave curve), most likely due to the fact that people generally view losses and gains differently (Levy, 1997). For example, Kahneman and Tversky (1979) postulated that the value function is influenced by people’s experiences when faced with a monetary loss (e.g., sensations of stress and pain) versus when faced with a monetary gain (e.g., sensations of pleasure). As a result of the reference dependency of this value function, any change in the current asset position *w* would most likely cause a change in preferences which could then result in different decisions (Plous, 1993; Levy, 1997).

Exceptions to Prospect Theory

Prospect theory adequately describes most risky decisions made by the rational decision maker. However, there are at least two exceptions to this decision theory. The first exception pointed out by Kahneman and Tversky (1979) is in the case of the negative prospect involving insurance. Typically when faced with a negative prospect, respondents preferred to take a risk over a sure loss. However, in the case of insurance premiums that are paid out monthly, semi-annually, or annually (i.e., a sure loss), Kahneman and Tversky showed that respondents were unwilling to take a gamble and risk paying a lot of money to replace, for example, a car or house no matter how small the risk. Instead, the respondents preferred to pay the certain loss of the premium. Thus, in this case, the decision maker was risk averse in the negative domain rather than risk seeking as predicted by prospect theory.

The second exception occurs in the case of gambles involving game shows—in particular the game show Deal or No Deal. Whereas Kahneman and Tversky (1979) showed that respondents were risk averse in the positive domain of the value function and risk seeking in the negative domain, decisions made during the game show Deal or No Deal resulted in a reversal of this effect. After observing decisions made during the game, it was found that when players were given the choice between taking the Banker's offer (a certain monetary gain that once accepted ends the game) or rejecting the offer to continue the game (a risk that varies in probability from round to round), the players typically chose the risk over the certain monetary prize. Thus, these decision makers are risk seeking in the positive domain rather than risk averse as prospect theory predicts. These results will be discussed in greater detail in the Application component of this essay.

Another exception to prospect theory was described by Jack Levy (1997). Levy found that prospect theory was inadequate, in part, due to the decision maker's dependency on a particular reference point or frame. Because people typically frame around their current asset position or status quo, when that reference point changes (e.g., the decision maker gets a raise or looses their job), it results in different preferences and ultimately different decisions (Bell, 1985; Levy, 1997). This is a great disadvantage because circumstances surrounding decisions are rarely static. In addition, when the conditions surrounding the decision changes, not only does the decision maker's status quo change, but also the way he or she chooses the reference point (Levy, 1997). As a result, it would be extremely difficult to predict which alternative an individual will choose based on prospect theory.

In the case of the game show Deal or No Deal, the conditions surrounding the decision to take the Banker's offer or to continue the game change with each round. When the player first enters the game, his or her reference point or status quo is their current asset position which is typically very low. That is, most players are chosen because they have a financial need that makes the possibility of winning a large amount of money more relevant to them. However, as the game progresses and various monetary offers are made by the Banker, the player's status quo changes and they are required to reframe each decision based on the probability of gaining or losing specified amounts of money. As a result of these dynamic conditions surrounding Deal or No Deal decisions and the reversal of the effect in the positive domain of the value function; prospect theory does not adequately explain the Deal or No Deal decision making process.

Regret Theory as an Alternative to Utility Theory

David Bell

Perhaps the singular goal of decision theory can be summarized as effectively and accurately modeling actual decision making behavior. However, none of the theories examined thus far have succeeded in modeling *all* types of decision making behavior. David Bell (1982) attempted to resolve this issue by including an additional factor into the model—regret. While examining decisions made under uncertainty (i.e., where the future outcome is uncertain but not necessarily riskless), Bell postulated that once a decision was made, the decision maker would feel either elation or regret. In other words, after the outcome occurs and the decision maker reviews their decision, if he or she determines that they made the wrong decision, then they will experience regret (Bell, 1985).

Psychological feelings of regret and their influence on the decision maker were not considered in expected utility theory or prospect theory models. However, building on the foundation of Bernoulli’s (1738/1954) utility theory and Von Neumann and Morgenstern’s (1953) expected utility theory, Bell (1982) hypothesized that many of the Von Neumann and Morgenstern axiom violations simply resulted from the decision maker’s desire to avoid feelings of “post decision regret” (Bell, 1982, p. 979) and labeled this influencing factor “decision regret” (Bell, 1982, p. 961). Bell postulated that the level of regret felt by a decision maker was influenced by their current asset position (i.e., wealth) and utility of money. In introducing this new concept, Bell attempted to objectively measure regret in terms of the positive or negative difference in assets received (i.e., final assets) and the highest asset value of the alternatives not chosen (i.e., foregone assets). Bell mathematically expressed regret in terms of a value function

(v) that captured the incremental changes in the utility of the difference in final assets received (X) and foregone assets given up (Y) and where $v(x)$ measured satisfaction with the final asset position and regret measured as $v(x)-v(y)$.

Rather than basing the decision on minimizing the maximum regret, Bell (1982) suggested that decision makers most likely consider tradeoffs against the value of assets received in order to minimize regret. For example, consider the case of regret symmetry. Bell described a situation where a farmer is faced with the following choices surrounding selling his crop (p. 963):

$A:(3,.5;7,.5)$

$B:(5)$

In other words, the farmer could sell his crop now for $5/bushel (a certain event) or later and take a chance at receiving either $3/bushel or $7/bushel (an equal risk).

Prospect theory would predict that the farmer would choose alternative *B* due to the desire to avoid risk. However, under regret theory, the farmer would take into consideration the following before making his decision: If he chooses to sell the crop now for the certain price of $5/bushel and later finds out that he could have sold it for $7, then he would realize that he lost $2/bushel and would experience regret. However, if he sold it for $5 now and later finds out that he could have sold it for $3, then he would be elated that he profited $2/bushel. Now, if he chooses to wait and sell his crops later for $3/bushel, then he would feel regret at not having sold earlier for $5 (a loss of $2/bushel). But if he chooses to wait and later sells for $7/bushel, then he would feel elated because he made an additional $2/bushel. Thus, whatever decision that the farmer makes would be based on the tradeoffs of waiting or not versus the value of the assets received. In this case, the decision was symmetrical in terms of the potential for regret and thus resulted in equal risk (Bell, 1982).

Graham Loomes, and Robert Sugden

At approximately the same time that David Bell (1982) was working on his version of regret theory, Graham Loomes and Robert Sugden (1982; 1983; 1987) were independently developing their own model of decision making based on regret which they also considered to be an alternative to expected utility theory. Loomes and Sugden based their alternative model on two basic assumptions: (a) people do experience regret and rejoicing (i.e., elation), and (b) people anticipate how they will feel upon making decisions under uncertainty and therefore, will take regret into consideration before making the decision. Loomes and Sugden (1987) postulated that as with utility theory, expected utility theory, and prospect theory, in regret theory individuals choose in such a way as to maximize expected utility. However, unlike the other decision theories, under regret theory, preferences are based on actions rather than prospects (i.e., probabilities; Loomes and Sugden, 1987).

Similar to Bell (1982), Loomes and Sugden (1982; 1983) felt that Von Neumann and Morgenstern's expected utility theory (1953) contained "holes" (i.e., it didn't explain all decision behaviors) that allowed axiom violations to occur. As a result, the effects of factors such as regret had been overlooked. Hoping to "fill the holes," Loomes and Sugden (1982) showed that when feelings of regret (and conversely rejoicing) were included as a factor in the decision making process, the decision maker acted in a rational manner (a basic tenet of all decision theories). Bell and Loomes and Sugden (1983) agreed that in the regret model, people tended to compare their current decision with what could have been if they would have chosen differently.

As a result they could experience regret or rejoicing. This experience along with feelings of regret or rejoicing would then influence any future decisions made (Loomes & Sugden, 1983).

Regret and Deal or No Deal

David Bell's (1982) example of "regret symmetry" (p. 964) and Loom and Sugden's (1982; 1983; 1987) description of decision making under regret can be applied to decisions made during the game show Deal or No Deal. For example, after the player opens the designated number of cases during a round, the Banker makes a monetary offer to the player which, upon acceptance by the player, will end the game. The Banker's offer is a fixed dollar value that has no risk, whereas continuing the game does have risk. If the player chooses to take the Banker's offer and then finds out that she has been holding the $1,000,000 case or that she could have gotten more money if she had only played another round, then the player will feel displeased (i.e., regret) with her decision to take the Banker's offer. However, if the player chooses to take the banker's offer and then finds out that any further play would have resulted in less money than she received by accepting the offer, then the player will feel pleased (i.e., elated or rejoicing) with her decision.

Bell (1982) considered the alternatives to be symmetrical when the value of the gain and loss from the two decisions were the same and referred to this situation as "regret symmetry" (p. 964). However, Deal or No Deal decisions are seldom symmetrical in this way due to the varying nature of the Banker's offer as compared to the dollar amounts remaining in play. In addition, if the player refuses the Banker's offer and accepts the risk, she continues the game by opening the designated number of cases (depending on the round) and based on the result, considers the banker's new offer. Thus, as the player is faced with a new decision in each round, her decisions may be influenced by her feelings of regret or pleasure from decisions made in previous rounds just as Loomes and Sugden (1983) suggested. In the case of this particular game show, this effect may be enhanced due to the audience's responses, supporter's suggestions, and host's comments.

Conclusion

Decision theory is a fascinating science that in actuality is a blend of two distinctly different yet related disciplines: psychology and economics. From a psychological point of view, individuals make decisions based on their personal preferences and frame of reference. From an economic point of view, individuals make decisions based on the expected loss or gain typically in terms of monetary value. However, decisions made by individuals are often made (either at a conscious or subconscious level) with both of these perspectives in mind and are also influenced by multiple variables such as the level of risk, regret, and other past experiences.

Although decision making may appear to be effortless or seamless on the surface, in reality, many assumptions and thought processes take place with each decision. Because of this, many theories of how the rational decision maker actually makes decisions have been posited over the last 100 years. In this essay, three theories were examined, compared, synthesized, and contrasted in order to determine which theory best explains the decision making process during the television game show Deal or No Deal. These theories are expected utility theory, prospect theory, and regret theory.

There are many reasons (from both economical and psychological points of view) for wanting to accurately model exactly how and why people make decisions. However, none of the models evaluated in this essay accurately describe *all* decision making behavior and therefore by themselves are not completely adequate to do so. Indeed, this may be an impossible task since decision making involves both objective and subjective inputs. However, each of the theories evaluated in this essay has merit and can be applied to specific decision making situations such as decisions made during the game show Deal or No Deal. To this end, expected utility theory certainly plays a part in the Deal or No Deal decision making process since the player's current asset position greatly influences their utility of money and ultimately the decision to take the deal or not. In addition, with this model, all of the axioms presented by Von Neumann and Morgenstern (1953) were met. However, there is more at play in Deal or No Deal decisions than just expected utility.

Prospect theory as depicted by Kahneman and Tversky (1979), added the concept of risk to the model and the respondent's behavior when facing risk. They found that when the respondents of their study were presented with gambles in terms of a gain, they were risk averse and when the gambles were presented in terms of a loss, the respondents were risk seeking. This resulted in an "S" shaped utility curve that was concave in the positive domain and convex in the negative domain. Although influenced by the respondent's current asset position and perceived utility, prospect theory failed to explain the decision making behavior of Deal or No Deal players. Indeed, Deal or No Deal players reacted conversely to risk and were risk seeking in the positive domain instead of risk averse as prospect theory would predict. Thus, prospect theory does not adequately describe the Deal or No Deal decision making process.

Regret theory as proposed by Bell (1982) and Loomes and Sugden (1982) attempted to describe the decision making process by including the concept of regret. These researchers showed that not only does expected utility play a role in the decision making process, but also feelings of regret or elation depending on the potential outcome. In other words, when the decision maker faces a decision, he or she often considers all of the potential outcomes and the good or bad feelings that might result if that outcome were to occur. When considered along with the expected utility, those feelings of regret (if they made a potentially bad decision) or elation (if they made a potentially good decision) would greatly influence the decision making process. Thus, although expected utility still plays a part in this decision making process, it can be overridden by the decision maker's strong feelings of regret or elation.

Regret theory does adequately explain the thought processes behind the Deal or No Deal player's decisions since the player is often given the opportunity to reflect on past decisions, the importance of the amount of money the banker is offering with respect to their needs (i.e., utility), and the potential to make a bad decision (i.e., regret). Thus, in this emotionally filled environment, it would appear that in addition to expected utility, regret plays an important role in decisions made during the game show Deal or No Deal.

DEPTH

SBSF 8221: CURRENT RESEARCH IN HUMAN DEVELOPMENT—DECISION ANALYSIS

Annotated Bibliography

Abdellaoui, M., Bleichrodt, H., & Paraschiv, C. (2007). Loss aversion under prospect theory: A parameter-free measurement. Management Science, 53(10), 1659–1674.

Summary. In order to evaluate loss aversion, Abdellaoui, Bleichrodt, and Paraschiv, (2007) devised a nonparametric method of determining utility based on eliciting utility midpoints from individuals. This method supported Kahneman and Tversky's (1979) original prospect theory "S"-shaped utility curve in that the positive domain of gains was concave while the negative domain of losses was convex. Thus Abdellaoui et al. believed that their parameter-free method could adequately elicit utility regardless of how loss aversion was defined. The authors did suggest that more research was necessary in order to standardize the definition of loss aversion.

Critical Assessment. This study focused on the development of a nonparametric measurement of utility so that parametric assumptions could be avoided. Unlike other methods, Abdellaoui et al. (2007) pointed out that this method of utility elicitation does in fact show convexity in the negative domain and concavity in the positive domain of the utility curve, thus supporting Kahneman and Tversky's original prospect theory as well as cumulative prospect theory. However, Abdellaoui et al. also discussed the potential danger of response errors to their method but felt that these errors would have minimal impact. In addition to response errors, Abdellaoui et al. described the difficulty of defining loss aversion but concluded that the elicitation method presented in this study was not dependent upon any specific definition of loss aversion and thus, would apply to both global and local loss aversion.

Value Statement. This new method of obtaining utilities is unique in that it does not rely on parametric assumptions and parameters. However, it is still complicated and many measurements need to be taken from the individuals under study. Although it provides empirical support for the prospect utility curve (i.e., risk averse for gains, risk seeking for losses), it will not adequately describe Deal or No Deal decisions since these decision makers are risk seeking for gains. Thus this method will not be used to help define Deal or No Deal decisions.

Baltussen, G., Post, T., & van Vliet, P. (2006). Violations of cumulative prospect theory in mixed gambles with moderate probabilities. *Management Science, 52*(8), 1288–1290.

Summary. In this study, Baltussen, Post, and van Vliet (2006) examined decisions based on the following stochastic dominance criteria: (a) second-order stochastic dominance, (b) risk-seeking stochastic dominance, (c) prospect stochastic dominance, and (d) Markowitz stochastic dominance. Stochastic dominance refers to the preference ranking of gambles based on utility or expected value. First order stochastic dominance simply describes the preferential ranking based on probabilities (e.g., event A has a higher probability of occurring than event B, thus A is preferred). However, in second-order stochastic dominance not only would event A have a higher probability of occurring, but it would also involve less risk than event B, thus appealing to risk averse decision makers. In addition, whereas the utility curve described under prospect theory is considered to be risk averse in the positive domain and risk seeking in the negative domain, Baltussen et al. assumed second-order stochastic dominance to be globally risk averse (i.e., risk averse over the *entire* domain). On the other hand, risk-seeking stochastic dominance is assumed by Baltussen et al. to be globally risk seeking (i.e., risk seeking over the *entire* domain). Prospect stochastic dominance describes the typical "S" shaped utility curve introduced by Kahneman and Tversky (1979) while Markowitz stochastic dominance describes a function that has convex *and* concave regions in *both* the positive and negative domains of the utility curve (Levy & Levy, 2002). To illustrate these differences in stochastic dominance, Baltussen et al. used the same mixed gambles that were presented in a study by Levy and Levy (2002). However, an additional problem was added in order to test second-order stochastic dominance. For all problems, the expected values were the same and all mixed gambles had equal probabilities. The results of the study showed that when Markowitz stochastic dominance was compared to prospect stochastic dominance, participants favored the Markowitz stochastic dominance model. In addition, when comparing risk seeking versus risk averse choices, the majority of participants exhibited risk aversion in the domain of losses and thus violated the risk-seeking stochastic dominance rule. In another gamble, the majority of participants preferred the second-order stochastic gamble over the Markowitz stochastic dominance gamble. Equating cumulative prospect theory with Markowitz stochastic dominance, Baltussen et al. concluded that cumulative prospect theory was not adequate to predict mixed gambles

Critical Assessment. In the examination of mixed gambles of equal probabilities, Baltussen, Post, and van Vliet (2006) compared the dominance effects of prospect stochastic dominance, Markowitz stochastic dominance, second-order stochastic dominance, and risk-seeking stochastic dominance. Baltussen et al. used and slightly modified Levy and Levy's (2002) original study to incorporate more comparisons. They tested 289 first year economics undergraduate students. It was not clear whether these students were paid or volunteered. It was interesting that the authors did not include a brief demographic breakdown of the participants. Thus, it is unknown whether the conclusions drawn from this study could have been biased by, for example, gender or age. Through the results of this expanded study, Baltussen et al. were able to confirm and clarify Levy and Levy's results. As a result, the evidence against using cumulative prospect theory to predict mixed gambles was strengthened by this study.

Value Statement. The results presented by Baltussen, Post, and van Vliet (2006) add to the general discussion about prospect theory and cumulative prospect theory. Mixed gambles are representative of financial and investment data and so these results help to determine the best decision model for that area of study. Although Deal or No Deal decisions could possibly be presented in terms of mixed gambles, this is not the most efficient way to express the decision. Thus, this information is not useful for determining how players make decisions in Deal or No Deal.

Brandstatter, E., Gigerenzer, G., & Hertwig, R. (2006). The priority heuristic: Making choices without trade-offs. *Psychological Review, 113*(2), 490–432.

Summary. In this article, Brandstatter, Gigerenzer, and Hertwig compared decision making theories based on Bernoulli's expected utility model (e.g., prospect theory and regret theory) with a new model—the priority heuristic—which is based on reasons (i.e., probabilities and outcomes). The authors believed that the Bernoulli-based models failed to adequately predict human decision making behavior because they were based on weights and summing functions that forced the decision maker to make tradeoffs. The proposed priority heuristic model is simply based on order (e.g., minimum gain, probability of minimum gain, and maximum gain) and rules (i.e., stopping rules and decision rule). As a result, Brandstatter et al. believed that the priority heuristic was able to more accurately predict decision making behavior. Whereas prospect theory and expected utility theory fail under conditions such as the Allias paradox[1], certainty effect, and reflection effect, the authors showed that the priority heuristic was able to model these special conditions. Brandstatter et al. described in great detail the steps involved in performing this heuristic for two-outcome gambles based on gains or losses and for more than two outcome gambles. Finally, the authors gave multiple examples under various conditions that confirmed the predictions made by their model.

Critical assessment. Brandstatter et al. considered the priority heuristic to be a better predictor of decision making behavior than Bernoulli-based decision theory models. Upon first examination, the priority heuristic for two-outcome gambles appears to simply corroborate prospect theory predictions. However, the authors point out that in situations where prospect theory often fails (e.g., Allias paradox, reflection affect, certainty affect, etc.), the priority heuristic is able to accurately predict the majority choice and thus, the authors conclude, the priority heuristic is the better model. The authors backed up their claims with many examples and a thorough discussion. As with any decision theory model however, there are limitations.

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[1] In 1953, Maurice Allais challenged the validity of expected utility's independence axiom (i.e., if $pX + (1-p)Z > pY + (1-p)Z$, then $X > Y$; Brandstatter, Gigerenzer, & Hertwig, 2006). Known as the Allais Paradox, this choice problem presented two decision sets (Brandstatter et al., 2006, p. 414):

A: ($100 million, 1.0)

B: ($500 million, 0.10; $100 million, 0.89; $0, 0.01)

and

C: ($100 million, 0.11; $0, 0.89)

D: ($500 million, 0.10; $0, 0.90)

Note that in the second decision set, the 89% chance of gaining $100 million was removed from both *C* and *D*. When making the comparison between the two decision sets, under expected utility, if the decision maker chooses alternative *A*, then he or she should also choose alternative *C*. However, the Allais Paradox showed that the majority of decision makers chose alternative *A* in the first set and alternative *D* in the second set thus resulting in a violation of the independence axiom.

The authors quickly pointed out that this model did not apply to situations where one gamble dominates the other or to situations where the expected values differ greatly. In addition, individual preferences for risk (i.e., a preference for risk seeking or risk aversion beyond what is rationally expected) as well as how the problem is represented can skew the model results as well. Regardless of these limitations, the authors suggested that the priority heuristic should be the foundational structure upon which future decision models are built. Other areas that the authors did not address are whether the model assumes rationality and whether the model is intuitive.

Value statement. This article brings to light a new way of predicting decisions that eliminates the necessity of weighting and summing and therefore, tradeoffs. In this respect, the model may be useful in conceptualizing how decisions are made during the Deal or No Deal game show. Of major concern for Deal or No Deal decisions is the ability of the player to think rationally under pressure and with a lot of noise, emotions, and distractions. Thus, if the priority heuristic is intuitive (even with all the extraneous noise) then an adaptation of this model may be able to adequately describe this decision process.

Campbell, S. (2005). Determining overall risk. *Journal of Risk Research, 8*(7/8), 569–581.

Summary. In this article, Campbell examines the quantitative aspects of risk and describes the additive effects of individual risks and the cumulative effects of risk. Campbell first defined risk in terms of the expected harm of an action. The term “harm” here equates to the disutility, costs, loss, or any other detrimental effects perceived by the decision maker which is measured on a utility scale. As a result, harm can be identified by a negative number (relative to a negative utility) and the opposite effect which Campbell called “good” can be identified by a positive number (relative to a positive utility). Campbell gives several examples to show the additive effects of risk in determining overall risk.

Critical assessment. Although informative, Campbell's definition and assessment of risk does not appear to present any new or novel approach to decision making. In fact, Campbell's risk-benefit analysis approach simply describes the typical decision making under risk approach that has been popular for many years. Although Campbell uses utility to construct the overall risk, the author points out that his study does not address the risk averse or risk seeking behaviors observed in prospect theory. In fact, Campbell's purpose in writing this paper was to simply define risk. He does this in terms of the relative harm (i.e., negative utility) or good (i.e., positive utility) of the outcomes.

Value statement. When making decisions, the rational decision maker typically begins with an assessment of risk or benefit. With this precept in mind, Campbell does define individual risk by explaining its components (harm and benefits) and their effects on overall risk. However, in terms of prospect theory, this paper does not add any new information but simply provides a beginning point for the discussion of utilities and their use in determining risk. In terms of general decision theory, Campbell's analysis of risk is similar to the decision making under risk procedure and does not add any new information.

Ding, M. (2007). A theory of intrapersonal games. *Journal of Marketing, 71*(2), 1–11.

Summary. In the case of conflicting preferences, an individual will wrestle with their inner-self (with respect to the id and superego) in order to resolve the conflict and make a decision. Ding (2007) referred to these multiple inner preferences as "selves" and sought to quantifiably describe this decision making process based on the integration of Freud's structure theory and Minsky's society of minds theory. Ding described the deliberate interaction of multiple selves using multi-person game theory. Specifically Ding created a "theory of intraperson games" (TIG) for variety seeking behavior (i.e., behavior in which individuals have choice diversity). For this new theory, Ding proposed a conceptual framework made up of four agents (i.e., efficiency agents, equity agents, behavior agents, and identity agents) that allowed for mathematically modeling individual decisions as an intraperson game that was applicable to a wide range of disciplines.

Critical Assessment. Ding (2007) presented a new decision theory model (a theory of intraperson games or TIG) based on psychology's interpretation of the mind as well as game strategy. Although often described qualitatively, Ding approached this theory from a quantitative point of view and presented several examples of how it could be applied in various disciplines. The theory appears to be unique, but because it involves four (sometimes conflicting) aspects or agents of the mind (both conscious and subconscious) to make the decision, it seems to overlap with some existing decision theories that are similarly based on emotions (e.g., regret theory and affect heuristic). The empirical study was limited in scope but the results did support the author's hypothesis.

Value Statement. The theory of intraperson games (TIG) approaches decision theory from the point of view of multi-person games while utilizing psychological agents based on the psychology of the id, ego, and superego in order to predict decision making behavior. The theory has merit in that it takes into account all aspects of psychological behavior while regret theory only takes into account feelings of regret. The affect heuristic is perhaps slightly more related to TIG because it takes into account all feelings, emotions, and recalled images (which may influence the identity agents) into the decision making process. This method could possibly be used to characterize Deal or No Deal decisions; however Ding (2007) recommended this method for predicting consumer behavior for advertising and marketing purposes.

Ert, E., & Erev, I. (in press). The rejection of attractive gambles, loss aversion, and the lemon avoidance heuristic. *Journal of Economic Psychology*. Retrieved November 25, 2007 from http://dx.doi.org/doi:10.1016/j.joep.2007.06.003

Summary. Treating Kahneman and Tversky's (1979) prospect theory as a starting point, Ert and Erev (in press) examined risk aversion with respect to the format in which a mixed gamble was presented. They found that when the high expected value mixed gamble was presented along with a status quo choice (i.e., $0 expected value) in a structured setting, then the majority (78%) of decision makers chose the risky gamble. Although still the majority, fewer participants (55%) chose to accept the risky gamble when it was presented without the status quo choice. In order to test whether the results were due to a "lemon avoidance heuristic," the authors repeated the experiment but changed the format of the setting. Instead of in a structured classroom setting, students were approached in the hallway. In this case, approximately half of each group chose the mixed gamble. In order to clear up any possibility of an indifference effect, the same experiment was repeated but with equal expected values. These results indicated that there were no random affects due to indifference. Ert and Erev also concluded that the lemon avoidance heuristic is an extension of prospect theory's loss aversion hypothesis. As such, this heuristic described decision making behavior when the situation exhibits "lemon" characteristics and should be rejected. In addition, Ert and Erev concluded that how a gamble is presented (i.e., with respect to a choice set or simply accepting or rejecting the gamble) can have significant influence on risk aversion.

Critical Analysis. This study supports the importance of framing or formatting a decision in order to avoid risk aversion. In addition, it shows that this effect can be enhanced by the lemon avoidance heuristic. Ert and Erev (in press) focused their study on mixed gambles and the status quo. It would interesting to see if the same effects occurred with positive only or negative only gambles and the status quo. However, this would be more characteristic of prospect theory which has already been studied in depth.

Value Statement. The results of this study could be indirectly applied to decisions made during the game show Deal or No Deal since these decisions do not follow prospect theory's risk aversion findings. In fact, Deal or No Deal players are typically risk averse in the positive domain. However, the idea of applying the format hypothesis and "lemon avoidance heuristic" to the Banker's offer could have merit. If the offer is formatted or framed correctly and the lemon avoidance heuristic is applied, it may result in more risk aversion and thus higher acceptance of the Banker's offer earlier in the game. As a result, the Banker wins because the player will exit the game with the least amount of winnings.

Levy, M., & Levy, H. (2002). Prospect theory: Much ado about nothing? *Management Science, 48*(10), 1334–1349.

Summary. Levy and Levy used prospect stochastic dominance (PSM) and Markowitz stochastic dominance (MSD) criteria to study investment decisions by business students and faculty in addition to professional finance managers in an effort to model their decision making behavior when faced with mixed gambles (i.e., both positive and negative alternatives but without certain alternatives). The authors compared these results with prospect theory gambles (i.e., either positive or negative and often containing certain alternatives) and showed that mixed gambles resulted in a reverse S-shaped utility function as opposed to prospect theory's S-shaped utility function. The authors believed that the reverse S-shaped function more realistically depicted real-life financial investment decisions.

Critical assessment. Levy and Levy were correct in pointing out that prospect theory completely overlooked the effect of mixed gambles on decision making. Thus, the authors contributed to the decision theory body of knowledge by evaluating the decision making process based on mixed gambles. However, by limiting the subjects in the study to only business students (both graduate and undergraduate), business faculty, and business finance professionals, the authors may have unintentionally biased the results since these educated, mathematically-minded, logical individuals may be better informed to make investment decisions than the typical investor. As a result, they may have been unintentionally braver and thus more willing to take a higher risk or unintentionally suspicious and less willing to take a high risk, which in either case, would skew the results of the study.

Value statement. By examining the effects of mixed gambles on investment decisions using stochastic dominance (PSM) and Markowitz stochastic dominance (MSD) criteria, Levy and Levy contributed to the main body of decision theory knowledge. However, this information does not help to explain the decisions made by players on the game show Deal or No Deal since those gambles are more representative of prospect theory gambles (i.e., presented in terms of a gains and with a certain alternative).

Munichor, N., Erev, I., & Lotem, A. (2006). Risk attitude in small timesaving decisions. *Journal of Experimental Psychology: Applied*, *12*(3), 129–141.

Summary. . In this study, Munichor, Erev, and Lotem investigated risk attitudes (i.e., risk seeking or risk averse) with respect to small, timesaving, monetary decisions based on personal experience. In order to study the effects of time-delayed monetary-based decisions, the authors performed four experiments in which participants were given two alternatives and asked to choose based on certain conditions. In the first two experiments, the conditions were timesaving in terms of delays and monetary payoffs. The third experiment simply looked at timesaving decisions while the fourth experiment repeated the second and third. The authors found that when participants are able to reliably rank the outcomes, they will prefer the alternative that gives the best outcome, regardless of whether it is risk seeking or risk averse. In addition, upon repeated trials, a learning curve takes place which results in less risk seeking behavior over time. These two properties are exhibited when the decisions are money-related but can also be extended to timesaving decisions. When reliable ranking of outcomes is not possible, the decision maker resorts to random choice.

Critical assessment. This paper discusses timesaving decisions that are money based in order to assess risk attitudes among the decision makers. The results of this research contradicted previous results in the literature. While adding to the body of decision theory knowledge, this result simply confirms that decision making is difficult to describe, reproduce, and predict. The authors were very thorough in their research and used a different random sample for each experiment. The authors suggested that the results could be used to help describe human behavior, especially when facing timesaving decisions.

Value statement. One interesting finding in this study is that when an experiment is repeated in multiple trials, the decision maker learns from past experience (decisions made) and slowly shifts from risk seeking to risk averse as the trials continue. Although the Deal or No Deal player is not faced with the exact same decision in each round of the game (as in the experiments presented here), they still move from risk seeking in the beginning of the game to risk averse as the game progresses. This may be due to the player's awareness of the limited number of rounds and pending end of the game or it may be due to the effects described in this paper. This concept warrants further investigation.

Novemsky, N., & Kahneman, D. (2005). The boundaries of loss aversion. *Journal of Marketing Research, 42*(2), 119–128.

Summary. In this article, the authors seek to define the boundaries of loss aversion in decision making with respect to risky decisions. A type of risk aversion, decision makers experience loss aversion when the possibility of a loss appears to be larger than a gain or if there is a significant negative change from the status quo. As a result, the decision maker will typically choose so as to avoid the loss. Closely linked to loss aversion, the endowment effect describes the value a decision maker places on an item that they own. Novemsky and Kahneman examined this endowment effect and loss aversion by examining the risks of buying and selling in a series of four experiments. The results of the experiments substantiated the endowment effect and showed that sellers in both risky and riskless gambles exhibited loss aversion. However, only sellers facing risky gambles exhibited risk aversion. In addition, the results showed that buyers do not experience loss aversion for money spent in a purchase. Based on these results, the authors made the following propositions about the boundaries of loss aversion. First, loss aversion is reflected by the value of the item in the exchange. Second, if the seller exchanges the item as intended, then they will not experience loss aversion. Third, in balanced risks, loss aversion is the only risk aversion under consideration.

Critical assessment. From a research perspective, the authors performed multiple experiments over several years to support their hypotheses. Although the experiments were well planned, some subjects in the experiment were paid while others were unpaid (e.g., students in their classes). This may have introduced a sampling bias that could possibly skew the results. This study confirmed the endowment effect among decision makers and also showed that loss aversion occurred in both risky and riskless decisions. As a type of risk aversion, it would be interesting to determine if loss aversion from the seller's perspective is related to regret (an aspect the authors did not address). If it is true that once endowed with an item, the seller values that item more, then the seller may allow his or her feelings of regret to directly influence the selling price of that item resulting in greater loss aversion. Perhaps this relationship should be addressed further.

Value statement. The authors have brought to light an aspect of decision making (i.e., loss aversion and the endowment effect) that has implications across many disciplines. For example, the authors described many marketing implications in which loss aversion may detrimentally affect the consumer's decision making behavior. In this case, marketers can frame advertising campaigns and manipulate consumers so as to avoid loss aversion. For example, when a purchase is viewed as being outside of the family budget, the consumer will experience loss aversion for the money spent on that item. To avoid this, the marketer will reframe the advertisement so that the purchase will seem like a necessary part of the budget rather than outside of it. As an example, consider an advertisement for a new high definition widescreen television. Typically, an item like this would be considered a luxury item that is outside of a normal family budget, thus spending money on this item would seem extravagant and would result in loss aversion on the part of the consumer. However, the advertisement can be framed to make the purchase look like it is a necessity, convincing the consumer that they need it rather than want it and thus avoid the feelings of loss aversion. In another example, marketers may give out samples of their product in order to endow the consumer with their product, resulting in an increase in brand loyalty. Thus, when replacing that item, the consumer will be more likely to purchase that brand at market price in order to avoid the loss of that item. When considering decisions made during the game show Deal or No Deal, the player must decide to take the deal (the Banker's certain offer) or continue playing the game at a risk. The player may experience loss aversion when faced with the decision to "deal or no deal." In this case, the player as the "seller" has an idea of the value of the game based on the amount of money left in play. The dilemma that the player faces is to determine whether the banker as the "buyer" is offering enough money to exchange for the chance to continue playing the game. Thus the player will experience loss aversion if the difference between the value of the game as they perceive it and the Banker's offer is large, which will result in the player rejecting the Banker's offer. Since the Banker's goal is to get the player to take the lowest offer and exit the game, loss aversion may be a beneficial effect of risky decision making for the Deal or No Deal player.

Peters, E., Vastfjall, D., Slovic, P., Mertz, C. K., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science, 17*(5), 407–413.

Summary. In this article, authors Peters et al., examined the decision maker's mathematical ability to process numbers and evaluate probabilities (i.e., numeracy) in order to make better decisions. In this paper, the authors report the findings of four studies that examined all aspects of numeracy. Thus, the authors examined the use of attribute framing in the first two studies since decision makers who are not capable of using numeracy in the decision making process, typically resort to using attribute framing. The last two studies examined the influence of numeracy on affects during the decision making process. Not surprising, the authors found that individuals who were mathematically competent (i.e., high-numeracy) were more likely to retrieve and use numbers to aid them in the decision making process and to transform numbers from one frame to another. In addition, high-numeracy individuals were able to draw more affective meaning from the numbers, thus enabling them to make better decisions. The authors suggested that low-numeracy individuals may need addition help (other than using numbers) when making decisions while high-numeracy individuals may need addition help in areas other than numbers.

Critical assessment. This study examines the use of numeracy in the decision making process and the interaction of numeracy with affects. As a result, the authors add a new dimension to the role of affects in the decision making process and continue the discussion of how decisions are made in general. The only area of concern for this study is the sampling method. The authors rely heavily on the university population from which to draw their sample. This would not necessarily be a problem if each study utilized the same sampling method. However, in the first study, participants were recruited from the general university population through advertisements and were given a small monetary incentive to participate. In the second and third studies, students from a psychology class were used for both studies (a convenience sample) while participants were drawn from a larger pool of psychology department members for the fourth study. It would seem that in order to directly compare the four studies and make inferences about decision makers in general, in each study participants should have been randomly recruited on either a volunteer or paid volunteer basis from the same population pool.

Value statement. Although this study does not relate to prospect theory directly, indirectly it describes decision makers who would resort to evaluating prospects objectively (high-numeracy) or subjectively (low-numeracy). In this respect, this study adds to the body of decision making knowledge and helps to further describe and define the decision maker. This information could help to explain why in the TV show Deal or No Deal, some players are able to adequately assess the risk of continuing play versus taking the Banker's offer while others are not. Typically those who are not able end up leaving the game with the least amount of money For example, high-numeracy (i.e., risk averse) players won on average $106,619.71 as compared to $12,561.23 for the low-numeracy (i.e., risk seeking) players in a study of the American version of the game show (see the Application component of this essay for more details).

Rieger, M., & Wang, M. (2008). What is behind the priority heuristic? A mathematical analysis and comment on Brandstatter, Gigerenzer, and Hertwig (2006). *Psychological Review, 115*(1), 274–280.

Summary. Rieger and Wang attempted to confirm the recently developed priority heuristic of Brandsatter et al. (2006). As described by Brandstatter et al., the priority heuristic is a series of simple decision rules which guide the decision maker's choice. This heuristic works well in most cases, however Rieger and Wang felt that the Brandstatter et al. study was limited because it excluded cases where one gamble dominated the other (i.e., stochastic dominance) and where the expected values of the gambles differed too much. Rieger and Wang examined these exclusions more closely in order to determine just how applicable this heuristic was to various decision environments. After analyzing Brandstatter et al.'s examples as well as their own, Rieger and Wang determined that in addition to the previously stated problems, there were other inconsistencies with the priority heuristic. For example, Brandstatter et al. used data that was specifically designed to show a deviation from the expected utility model. Thus, due to this limitation, Rieger and Wang felt that Brandstatter et al. failed to prove that the priority heuristic was a viable model for all decision types. Upon further testing, Rieger and Wang concluded that the priority heuristic was an oversimplified decision model that worked only within a limited range of probabilities. Thus, they deemed it unsuitable for more general cases. As a result, Rieger and Wang rejected the priority heuristic and instead supported the use of the more conventional and widely accepted prospect theory or cumulative prospect theory.

Critical Assessment. The priority heuristic is a new decision model presented by Brandstatter, Gigerenzer, and Hertwig (2006). As such it is untested with regard to every possible decision choice. Brandstatter et al. did discuss some cases where the heuristic did not apply. However, Rieger and Wang (2008) thoroughly examined the priority heuristic and found that it was not a good predictor of actual decision behaviors. Although this may be the case for complicated decisions, there may still be an application where the priority heuristic is well suited. This would require more research and critical examination. However, at this point, the evidence presented here points to cumulative prospect theory as the superior decision model for the majority of cases.

Value Statement. This study points out many of the inconsistencies and inadequacies of using the priority heuristic for decision making. However, within a limited range for simple two-outcome decisions, this may still be a viable model. For example, it could prove useful in evaluating decisions made during the game show Deal or No Deal. However, much more research needs to be done to confirm this.

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2004). Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk and rationality. *Risk Analysis*, *24*(2), 311–322.

Summary. In this study, Slovic, Finucane, Peters, and MacGregor examined how humans evaluate risk based on subtle affects. The process of thinking and decision making can be categorized into two systems—experiential and analytic. Slovic et al. address the experiential system of decision making with respect to something they call the "affect heuristic." The affect heuristic is the process of applying past experiences, images, beliefs, emotions, etc. (i.e., affects) to current decisions in order to perceive the potential risk or benefit of the outcome. The affect heuristic alone can influence decisions, but most likely the decision maker utilizes the affect heuristic (whether consciously or subconsciously) in conjunction with analytical reason to make decisions. Emotionally driven, the affect heuristic can itself be influenced by time and information constraints resulting in poor decisions. In addition, the affect heuristic can be manipulated by outside factors (such as advertisements) in order to sway decision makers. The affect heuristic may also be guided by inherent biases that will also influence the decision. However, even with these possible weaknesses, the affect heuristic along with reason and rationality can help decision makers make a well-rounded decision.

Critical assessment. The authors use the results of previous research studies to define and describe a new decision making heuristic called the affect heuristic. Although they were thorough in their assessment, it is easy to pick and choose the research studies that are relevant to and fit the theory rather than try to prove it scientifically based on empirical evidence. In this case, the authors only presented studies that supported their theory. It is not necessarily wrong to draw from other's research and propose new theories, but this should be followed-up with a well-defined, statistically-designed, research study to confirm the authors' theories.

Value statement. The affect heuristic explains a lot of the decision making behavior that is based on emotions or feelings (i.e., experiential). In terms of expected utility theory, the authors state that affective feelings are the basis of utility. Extending this further into prospect theory, the affect heuristic can be used to explain the perception of risk (i.e., in terms of gains or losses) that frames the decision maker's reference point. Indeed, Kahneman and Tversky (1979) stated that along with the decision maker's current asset position, their experiences also influence the prospect theory value function. In terms of decisions made during the game show Deal or No Deal, it is likely that the affect heuristic plays a role in determining the perceived risk or benefit of taking the Banker's offer to continue the game. This may be especially true because in some rounds, the announcer reminds the player of their background and experiences in the hopes of eliciting emotion from the player that will sway their decision.

Slovic, P., & Peters, E. (2006). Risk perception and affect. *Current Directions in Psychological Science, 15*(6), 322–325.

Summary. In this article, Slovic and Peters described risk in terms of the subtle intuitive feelings that stem from past experiences. Rather than fierce emotions such as anger or fear, Slovic and Peters were concerned with the subtle, underpinning emotions that they labeled "affects." The term "affect" takes into account both good and bad feelings that are experienced either consciously or subconsciously which are used to differentiate the qualities of a stimulus. The "affect heuristic" then is the term used to describe the decision maker's dependence upon affects to guide the decision making process. In today's fast paced environment, decisions often have to be made quickly and without available analytical information. In this case, often the fastest, easiest, and most efficient way to make the decision is by utilizing the affect heuristic. Even though the affect heuristic is based on feelings and emotions, this does not preclude rationality in the decision making process. Slovic and Peters pointed out that since intuitive feelings are associated with basic survival instincts, these "gut feelings" are rational and are enhanced by current analytical decision making techniques. In addition, affect directly influences the decision maker's judgment of risk and benefit. Slovic and Peters also pointed out that affects are insensitive to probabilities (referred to as probability neglect). In other words, when the decision maker focuses on the bad outcome (due to the affect heuristic), he or she will ignore the small likelihood of that outcome happening. Focusing on affects will also result in insensitivity to numbers. This is representative of prospect theory in that the prospect utility (i.e., value function) diminishes as the number of items under study increases.

Critical assessment. Slovic and Peters simply changed venues to publish the same base information on the affect heuristic. For the most part, the information presented here contributed little new information to the discussion of decision theory. The authors did point out some influencing factors on affect and illustrated them with examples. Finally, the authors suggested areas of future study including understanding how affects protect or hurt the decision maker.

Value statement. This article simply repeats the information presented in the previous articles by Slovic. This information is useful to discuss how affect interplays with prospect theory to influence the decision making process with regard to risk analysis.

Slovic, P., Peters, E., Finucane, M. L., & MacGregor, D. G. (2005). Affect, risk, and decision making. *Health Psychology, 24*(Suppl. 4), S35–S40.

*Summary.*In this study, the authors continue the discussion of affect and perceived risk in the decision making process. When a person experiences an affective response, he or she, knowingly or unknowingly, quickly and automatically assesses the situation based on past experiences, emotions, recalled images, and other feelings to distinguish between good and bad, positive and negative qualities. The authors refer to a reliance on this response in decision making as the affect heuristic. Typically, decisions are made based on two modes of thinking: analytic and experiential. Affects and the affective response are encapsulated in and the basis for the experiential mode. Although the analytic mode is equally important in decision making, this type of thinking is slow and not automatic. However, the affective response happens quickly and somewhat automatically in response to a stimulus. Thus, affects are sometimes treated as the primary motivating behavior in decision making. The rational decision maker uses experiential thinking (including affects) to support, supplement, and guide analytic thinking in order to make decisions.

Critical assessment. This article continues the discussion of the affect heuristic and risk perception in decision making. However, no new information is presented. This article is similar to the Slovic, Finucane, Peters, and MacGregor article (2004) and at times simply repeats the information in the 2004 article. It was hoped that more light would be shed on the affect heuristic and its role in the decision making process, but this article was simply a repeat of the previous study.

Value statement. This study did not shed any new light on the concept of the affect heuristic and its relationship to risk perception and prospect theory. The information presented in this article will be utilized in conjunction with the Slovic et al. (2004) article to show that the affect heuristic can be used to describe decisions made during the game show Deal or No Deal.

Steel, P., & König, C. J. (2006). Integrating theories of motivation. *Academy of Management Review, 31*(4), 889–931.

Summary. In an attempt to better explain decision making behavior over time, Steel and König looked for factors that were common among four decision theories (i.e., picoeconomics, expectancy theory, cumulative prospect theory, and need theory). They identified four core factors (i.e., time, value, expectancy, and losses versus gains) that when integrated resulted in a new decision model called temporal motivational theory. The authors described this theory mathematically by expanding and modifying the matching law equation. Hierarchically, temporal motivational theory is very complex because it takes into account more factors than each component theory. Although cumbersome, it is the very complexity of this model that allowed the authors to describe decision making behaviors such as procrastination, stock market behavior, job design, and goal setting.

Critical assessment. Steel and König created a new decision making theory called temporal motivational theory in order to better explain decision making behaviors. In doing so, the authors choose to integrate four different theories that held some commonalities into the temporal motivational theory. Noting that the temporal motivational theory is cumbersome and difficult to use, the authors recommended that the choice of theory to explain decision making behavior should be based on simplicity. However, by stating that the simplest theory is always the best, it appears as if the authors are negating their work. If the currently-available simpler theories are sufficient, why would their complex theory ever be used? Even so, the authors do give some examples of how their theory can be applied. Also, there is some merit to the idea of integrating theories in order to explain specific decision making behaviors (such as Deal or No Deal) that are inadequately explained by a single existing theory.

Value statement. Steel and König presented information on four decision making theories in an effort to show that there were common factors among them that could be integrated to create a new theory called temporal motivational theory. Temporal motivational theory incorporates an extension of prospect theory called cumulative prospect theory as well as aspects of expected utility theory (expectancy theory), both of which have contributed to understanding the decision making behavior of players during the game show Deal or No Deal. However, since time is not a factor in Deal or No Deal decisions (they must be made within minutes of the Banker's offer), temporal motivational theory does not appear to be an appropriate theory to explain this process. However, the idea of integrating theories to explain the Deal or No Deal decision making process is intriguing and could be done if the appropriate theories are identified.

Stewart, N., Chater, N., Stott, H. P., & Reimers, S. (2003). Prospect relativity: How choice options influence decision under risk. *Journal of Experimental Psychology, 132*(1), 23–46.

Summary. Concerned with the limitations of expected utility theory and prospect theory in explaining decisions made under risk, Stewart, Chater, Stott, and Reimers investigated the effect of context on risky decisions. They performed multiple experiments in which the subjects were presented with risky prospects and asked to either make up the amount they would be willing to pay to play the gamble (i.e., a certainty equivalent) or to choose from a provided list of certainty equivalents. Each experiment varied the conditions under which the prospects were presented. In each case, the authors showed that the certainty equivalent was chosen with respect to the accompanying prospect. In other words, the context of the problem affected the outcome. Stewart et al. referred to this effect as prospect relativity.

Critical assessment. The authors were extremely thorough in presenting their argument and performed numerous experiments in order to prove their point. In addition, they compared their proposed prospect relativity theory to other published theories (e.g., expected utility theory, prospect theory, regret theory, and stochastic difference model) in order to show that prospect relativity is a valid theory. They concluded that theories such as expected utility theory and prospect theory (where prospect utilities are independent of each other) do not predict context effects while theories such as regret theory (where prospect utilities are dependent) do to some extent. In performing the experiments, the authors used several different samples which were somewhat inconsistent. For example, in some samples the subjects were either paid a small amount or given course credit for participating while subjects in other samples were not compensated. In addition, students (both graduate and postgraduate) were used for all of the experiments except one in which visiting professionals were used. In addition, the number of subjects in each study varied from as few as 14 to as many as 91. Although the mean age is similar for each group (with the exception of the professionals), the majority of participants are women. It would seem that in order to eliminate age, gender, and perhaps professional experience effects, and in order to make direct comparisons between the experiments, the authors should have standardized the number and types of participants in each study.

Value statement. The information presented in this study is novel and brings to light another side of decision making under risk. The author's studies showed that decisions are often made in context. In other words, when making the decision, each prospect is considered with respect to other prospects in the decision. The authors found that their model was similar to regret theory in which the decision maker takes into account the possibility of feeling regret or elation with each possible outcome before making the decision. Since decisions made during the game show Deal or No Deal can be described (at least in part) by regret theory, it would follow that prospect relativity may be useful in helping to describe this decision making process as well.

Literature Review Essay

Introduction

The Breadth component of this Knowledge Area Module examined three decision theories (i.e., expected utility theory, prospect theory, and regret theory) with respect to decisions made during the American version of the television game show "Deal or No Deal." It was shown that decisions made during Deal or No Deal tended to violate the principles of prospect theory. That is, prospect theory predicts that the decision maker will be risk averse when the gamble is based on gains and risk seeking when the gamble is based on losses (Kahneman & Tversky, 1979). Conversely, the Deal or No Deal player is risk seeking when presented with a positive gamble during the game show. Thus, prospect theory does not adequately describe the Deal or No Deal decision making process.

Regardless of this finding, prospect theory remains a prominent decision model that is still being examined and modified today. In addition to prospect theory's risk aversion, Kahneman and Tversky (1979) determined the following decision making effects: (a) certainty effect in which decision makers overweight probabilities associated with certain alternatives; (b) reflection effect in which decision makers reverse their preferences depending on whether they are based on gains or losses; (c) isolation effect in which decision makers disregard shared characteristics among alternatives and focus only on distinguishing characteristics resulting in inconsistent preferences. Due to the importance of prospect theory's findings and the escalation in decision theory research, the purpose of this essay is to examine recent advances in decision theory in order to determine if any new information or modifications will help explain the Deal or No Deal decision making process.

Stochastic Dominance

Although extremely popular, Levy and Levy (2002) pointed out that prospect theory was limited by Kahneman and Tversky's (1979) presentation of positive only or negative only gambles. Levy and Levy felt that the resulting S-shaped utility function was not representative of real-life financial decisions since, in reality, people are often faced with decisions involving mixed gambles that include both gains and losses. Thus, Levy and Levy studied the effect of mixed models on financial investment decisions using two criteria: prospect stochastic dominance and Markowitz stochastic dominance. With respect to investment and financial criteria, prospect stochastic dominance describes the family of "S"-shaped value functions (i.e., concave with respect to gains and convex with respect to losses) and incorporates mixed gambles and a change in wealth. In addition, prospect stochastic dominance has no certainty effect. On the other hand, Markowitz stochastic dominance describes value functions that are concave with respect to losses and convex with respect to gains. (In a later study, Baltussen, Post, and van Vliet (2006) would examine, in addition to these, second-order stochastic dominance and risk-seeking stochastic dominance in an effort to confirm and clarify Levy and Levy's results.)

In this study, Levy and Levy (2002) presented subjects with four gambles or "tasks." The subjects were asked to consider investing $10,000 in one of two stocks. After reviewing the potential outcomes in terms of dollars gained or lost (i.e., mixed prospects), the subjects would then choose an alternative (i.e., stock) based on the outcomes and their associated probabilities. The authors found that in this scenario, decision making more closely followed a reverse S-shape (i.e., Markowitz stochastic dominance) curve rather than the S-shaped curve predicted by prospect theory. In a second experiment, students were tested to determine their choices under the same basic scenario but with more than two equally likely outcomes. Once again, the S-shaped curve was rejected in favor of a reverse S-shaped curve. Lastly, in an effort to determine if any bias occurred in their sample, Levy and Levy (2002) repeated Kahneman and Tversky's (1979) study in which positive only and negative only gambles were presented. The results of this third experiment mirrored those of Kahneman and Tversky's original study on prospect theory indicating that there was no sampling bias.

Levy and Levy (2002) believed that by using positive only or negative only gambles, prospect theory unrealistically framed investment decisions and perhaps introduced bias. As a result, Levy and Levy chose to test mixed gambles of both positive and negative alternatives but without certain alternatives in order to eliminate the certainty effect. Levy and Levy concluded that the resulting reverse S-shaped Markowitz function more accurately depicted real-life investment decisions. Thus, Levy and Levy rejected the S-shaped preference curve predicted by prospect theory in favor of the reverse S-shaped curve predicted by Markowitz stochastic dominance, thereby resulting in an improved decision making process for investment decisions.

Picking up where Levy and Levy (2002) left off, Baltussen, Post, and van Vliet, compared mixed gambles based not only on Markowitz stochastic dominance and prospect stochastic dominance, but also on second-order stochastic dominance and risk-seeking stochastic dominance. Similar to Levy and Levy's results, the participants of the Baltussen et al. study rejected prospect stochastic dominance in favor of the Markowitz stochastic dominance model. However, Baltussen et al. noted that the results were consistent with cumulative prospect theory. Because of this, Baltussen et al. considered Markowitz stochastic dominance to be equivalent to cumulative prospect theory.

An examination of risk seeking versus risk averse choices by Baltussen, Post, and van Vliet (2006) showed that most participants exhibited risk aversion in the domain of losses and thus violated the risk-seeking stochastic dominance rule. Additionally, Baltussen et al. compared second-order stochastic dominance gambles to Markowitz stochastic dominance gambles. In this case, the majority of participants preferred the second-order stochastic gamble. However, since establishing that Markowitz stochastic dominance was equivalent to cumulative prospect theory, Baltussen et al. concluded that cumulative prospect theory failed in this case.

Although the Markowitz stochastic dominance model may be able to adequately predict mixed gambles, this model is not easy to use by typical decision makers who may or may not be able to recognize mixed gambles. In addition, not every gamble is a mixed gamble. For example, gambles presented to players during the game show Deal or No Deal are not mixed gambles and are more representative of prospect theory gambles (i.e., presented strictly in terms of gains or losses). Thus, the Markowitz stochastic dominance model does not apply to Deal or No Deal gambles. In addition, in order to use prospect theory, most mixed gambles can be represented or reframed as positive only (i.e., in terms of minimum gain and maximum gain) or negative only (i.e., in terms of minimum loss and maximum loss) prospects as Brandstatter, Gigerenzer, and Hertwig, (2006) did or they can be reframed in terms of loss aversion as Novemsky and Kahneman (2005) described.

Loss Aversion and the Endowment Effect

Loss aversion is a type of risk aversion (as described in prospect theory; Kahneman & Tversky, 1979) which occurs when there is a significant negative change from the status quo resulting in a loss that appears to the decision maker to be larger than a gain (Novemsky & Kahneman, 2005). When this occurs, the decision maker will typically choose to avoid the loss. The endowment effect describes the behavior of the decision maker when they own an item that they may lose (e.g., voluntarily through the sale of that item). Once endowed with that item (i.e., once they own it), the decision maker will value it more than if they did not own it and thus as the seller, will often demand more money for the item than the buyer is willing to pay. To examine risky selling, Novemsky and Kahneman performed an experiment in which they endowed the subjects with an item (such as a coffee mug). Under equal probabilities, the subjects then choose to both keep the item and gain a certain amount of money or lose the item and gain no money. If the subject refused the gamble, they simply kept the item and lost nothing. To examine risky buying, subjects were given the choice between receiving the item and paying nothing or paying some money and receiving nothing.

In order to study loss aversion and the endowment effect, Novemsky and Kahneman (2005) tested several hypotheses. The first hypothesis tested whether sellers expected to be paid more for an item than the buyer or chooser was willing to pay for it (i.e., the endowment effect). The results of this experiment substantiated the endowment effect by showing that the seller's willingness to accept a price (i.e., the minimum amount of money the seller was willing to take in exchange for an item that they owned) was greater than the certainty equivalent of the buyer (i.e., the minimum amount of money the buyer would choose over the item). Thus, once someone owns an item, they value it more highly. Novemsky and Kahneman described this as the utility of ownership. However, similar to the utility of money, the value of the item owned is subjective and varies from person to person.

The second hypothesis examined whether buyers considered money that is typically used for the exchange of goods to be a loss (i.e., loss aversion). The results of this experiment showed that from the buyer's perspective, the highest price they were willing to pay for an item was not significantly different from their certainty equivalent. This is not surprising because to the buyer, the certainty equivalent represented the boundary between how much the item was worth (i.e., how much they would be willing to pay for it) and how much they would accept to not purchase it. If buyers felt loss aversion towards the purchases (i.e., they were unwilling to spend their money), then the certainty equivalent would be significantly less than the price they would be willing to pay for the item. However, that was not the case and Novemsky and Kahneman (2005) concluded that buyers do not experience loss aversion for money spent to purchase goods.

The third hypothesis examined by Novemsky and Kahneman (2005), determined whether the amount of money necessary to accept a risk was equal to the subjects' willingness to accept the risk (i.e., there were no other sources of risk aversion beside loss aversion). When comparing risky to riskless selling prices, Novemsky and Kahneman showed that sellers exhibited loss aversion in both risky and riskless gambles. However, risk aversion was only exhibited by sellers facing risky gambles. Thus, Novemsky and Kahneman concluded that there was no other type of risk aversion other than loss aversion.

From these experiments Novemsky and Kahneman (2005) concluded that buyers do not experience loss aversion for money spent in a purchase and that there is no other risk aversion than loss aversion. Novemsky and Kahneman also suggested that the more an endowed item is valued, the more loss aversion the person will experience. In addition, sellers will not experience loss aversion if they exchange for an item as intended. Thus, loss aversion is an aspect of risk aversion that can be used along with the endowment effect to manipulate the decision maker. For example, in the game show Deal or No Deal the player is endowed with a case containing an unspecified amount of money. At the end of each round of opening cases to reveal the dollar amounts hidden inside, the player is offered a chance to take the Banker's offer and end the game, ultimately selling his or her opportunity to continue and possibly win more. As the buyer, the Banker's offer is always less (and sometimes significantly less) than the highest dollar amount remaining in play and therefore, of less value than the player/seller believes the game is worth. Thus, the player feels loss aversion which may lead to a poor decision on their part. If the Banker really wants the player to end the game (for example when $1,000,000 is still left in play), then he will increase his offer so that the player will not feel loss aversion and be more willing to take the offer.

This type of manipulation is not necessarily unfavorable to the Deal or No Deal player who also experiences loss aversion. However, most players of this game show are risk seeking and so would most likely continue to play, even to their detriment. But this is just one aspect of loss aversion that can be considered. Another aspect is to evaluate loss aversion using a nonparametric method of measuring utility as described by Abdellaoui, Bleichrodt, and Paraschiv, (2007).

Loss Aversion and Utility Elicitation

Summary. Loss aversion plays an important role in risky decisions since most decision makers would rather avoid a loss. Loss aversion can be defined as either global (i.e., loss aversion over the entire domain) or local (i.e., loss aversion measured at a specific reference point on the utility curve). Abdellaoui, Bleichrodt, and Paraschiv, (2007) determined that regardless of how loss aversion is defined, it occurred at both the individual and aggregate level. However, the amount of loss aversion experienced depended on the definition of loss aversion which would affect how it was measured, thus making it difficult to measure an individual's attitude towards loss. No matter how it is defined, Abdellaoui et al. questioned whether loss aversion could be measured independently of the shape of the utility curve. However, Abdellaoui et al. believed that a nonparametric method of eliciting utility would be applicable regardless of the definition of loss aversion.

In order to accurately measure loss aversion, utility needs to be calculated. However, calculating utility is often difficult because of the parameters and parametric assumptions. Thus, Abdellaoui et al., (2007) approached loss aversion nonparametrically and also by considering decisions at the individual level. Under this parameter-free method, complete utility as defined by prospect theory can be measured and consequently, the degree of loss aversion. For this study, Abdellaoui et al. focused on individuals making decisions under risk for two-outcome monetary prospects under the following assumptions: (a) the individual will be able to rank-order prospects and make preferences or remain indifferent, (b) the individual will always prefer more money, and therefore, (c) the individual will choose so as to maximize overall utility. In addition, in this study outcomes are represented as gains or losses with respect to the status quo (for this study, status quo is $0).

Under prospect theory, decision makers often weight the probabilities associated with a gain or loss. These weights are subjective and previous research has shown that decision makers tend to underweight large probabilities while small probabilities are overweighted (Abdellaoui et al., 2007). Thus, if a loss carries a small probability, the individual tends to overweight it, making it more attractive with respect to a sure loss (such as in the case of a lottery where the probability of winning can be as small as 1/1,000,000 while the sure loss is $1 to play). In addition to the effects of this weighting bias on the measurement of loss aversion, Abdellaoui et al. discussed the lack of a uniform definition of loss aversion which affects subsequent estimates of loss aversion. Since there is no agreed upon single way to measure loss aversion under prospect theory, Abdellaoui et al. set about to elicit one based on a choice-based experiment using 48 paid economics students. The prospects were based on hypothetical monetary values that were substantially larger than any student’s income thus ensuring that the utility function would be curved.

The results of this study confirmed the decision maker’s tendency to underweight probabilities. In addition, Abdellaoui et al. (2007) confirmed the S-shaped utility curve of prospect theory (i.e., concave for gains, convex for losses) on both the aggregate and individual levels. The reflection effect was more prevalent at an aggregate level than at an individual level. Abdellaoui et al. concluded that this nonparametric elicitation of utility midpoints method supported Kahneman and Tversky’s (1979) original prospect theory as well as the subsequent cumulative prospect theory model. In addition, the authors stated that this method was efficient and sequential but may be minimally influenced by response error. However, Abdellaoui et al. suggested that more research needs to be undertaken in order to standardize the definition of loss aversion.

The method of utility elicitation described by Abdellaoui et al. (2007) may adequately describe loss aversion among decision makers that are presented with a series of gambles, but it most likely will not describe Deal or No Deal decisions because these decisions do not follow the S-shaped utility curve described by Kahneman and Tversky (1979). By measuring utility nonparametrically, Abdellaoui et al. took one step away from the original parametric models. Another degree of separation from the original models is to model human decision making behavior using a heuristic such as those described by Brandstatter, Gigerenzer, and Hertwig, (2006; i.e., priority heuristic), Slovic, Finucane, Peters, and MacGregor (2004; i.e., affect heuristic), and Ert and Erev (in press; i.e., lemon avoidance heuristic).

The Priority Heuristic

Past research has shown that the expected utility model does not adequately model all human decision making behavior. In addition, prospect theory has many exceptions that limit its applicability to every decision type. Thus, rather than basing decisions on Bernoulli-based functions that use weights and summations, Brandstatter, Gigerenzer, and Hertwig, (2006) introduced the priority heuristic decision model that uses reasons (i.e., probabilities and outcomes). This priority heuristic model is based on lexicographic rules which describe the way the decision maker orders the reasons before selecting one. For example, in the case of a simple two-outcome gamble, the decision maker first examines all of the outcomes and the probabilities associated with each (e.g., maximum gain, minimum gain, and their probabilities). Next, the decision maker orders the reasons. This is referred to as the priority rule. Based on previous research, Brandstatter et al. determined that decision makers prefer to consider outcomes over probabilities which indicate that there is a preference to base decisions on subjective factors such as feelings. Additionally, the decision maker tends to consider the potential loss (i.e., minimum gain) before the potential gain (i.e., maximum gain) which further illustrates risk aversion in the positive domain of gains. Thus, based on this evidence, Brandstatter et al. presented a priority rule for ordering simple two-gamble decisions: minimum gain, probability of minimum gain, and maximum gain. (Note that since this priority rule represents only a two-gamble decision, the probability of a maximum gain is the compliment of the probability of the minimum gain and thus is implied.)

Decision theories based on the Bernoulli model (e.g., prospect theory) do not require a stopping rule because they are exhaustive in including all of the available information into the maximum utility or expected value calculation. However, heuristics are limited in this sense and so require a rule that defines how the final choice should be made. This rule is based on an aspiration level of 1/10th or more of the maximum gain. This magnitude is a fixed parameter that is easy for the decision maker to estimate and would be enough to convince the decision maker to either stop or keep going. Based on this, the complete priority heuristic for two-outcome gambles with respect to non-negative prospects as presented by Brandstatter et al. (2006) is:

> *Priority rule*: Go through reasons in the order: minimum gain, probability of minimum gain, maximum gain.
>
> *Stopping rule*. Stop examination if the minimum gains differ by 1/10 (or more) of the maximum gain; otherwise, stop examination if probabilities differ by 1/10 (or more) of the probability scale.
>
> *Decision rule*. Choose the gamble with the more attractive gain (probability). (p. 413)

In other words, if the difference in minimum gains is greater than 1/10th of the largest maximum gain, then stop examining the reasons and choose the gamble with the largest *minimum* gain (see Table 2, first decision set; Brandstatter et al., 2006). However, if this is not the case (as in the second decision set in Table 2), then do not stop, but next examine the probabilities of minimum gain. If the difference between these probabilities is greater than 1/10th of the probability scale, then choose the outcome with the lowest probability of the *minimum* gain. Otherwise, choose the outcome with the largest *maximum* gain. Brandstatter et al. developed a similar heuristic for non-positive prospects as well as for more than two outcome gambles. Brandstatter et al. believed that by following these rules, the decision maker could avoid choosing the worst possible outcome.

Table 2. The Priority Heuristic Applied to Two-outcome Non-negative Gambles as Described by Brandstatter, Gigerenzer, and Hertwig, (2006)

	Priority Rule			**Stopping Rule**			**Decision Rule**
Gamble 1	Min. Gain	P(Min. Gain)	Max. Gain	Min. Gain Difference		Aspiration Level ($1/10^{th}$ of max. gain)	
$A: (\$200, .5)$ $B: (\$100)$	$0 $100	0.5 1.0	$200 $100	$(\$100 - \$0)$ $= \$100$	$>$	$(\$200 \times .1)$ $= \$20$	Stop, choose *B*
	Priority Rule			**Stopping Rule**			**Decision Rule**
Gamble 2	Min. Gain	P(Min. Gain)	Max. Gain	Min. Gain Difference		Aspiration Level (1/10th of max. gain)	
$A: (\$2000, .5)$ $B: (\$100)$	$0 $100	0.5 1.0	$2000 $100	$(\$100 - \$0)$ $= \$100$	$<$	$(\$2000 \times .1)$ $= \$200$	Go to next reason
				Prob. Differences		(1/10th of prob. scale)	
				$(1 - 0.5)$ $= 0.5$	$>$	(1×0.1) $= 0.1$	Stop, choose *A*

Interestingly, Brandstatter et al. (2006) tested this priority heuristic against many of the conditions under which prospect theory fails (e.g., Allias paradox, reflection effect, certainty effect, etc.) and found that the priority heuristic was able to overcome these effects and accurately predict the majority choice. As a result, Brandstatter et al. believed that their model was better than prospect theory or expected utility theory. However, every decision model has limitations and the priority heuristic is no exception. For example, an individual’s propensity for risk will affect the priority heuristic. In addition, situations where one gamble dominates the other or where the expected values differ greatly will also affect the results.

Rieger and Wang (2008) further examined this priority heuristic in order to determine its limitations. They determined that because Brandstatter et al. (2006) used data from other studies that were specifically designed to show differences based on expected utility, that the results were not representative of true human decision making behavior. In addition, they tested the priority heuristic against cumulative prospect theory and expected utility theory and found that the priority heuristic always settled on the certain outcome, even when it was not the best decision. As a result, Rieger and Wang suggested that the priority heuristic was an oversimplified decision model that was applicable to only a very limited number of cases and that the decision maker should resort to using the more widely accepted cumulative prospect theory model.

As with any decision model, there are pros and cons and specific limitations. The priority heuristic is so new that it is still being tested and perhaps refined. However, it is this very simplicity that makes it attractive in predicting decisions during the game show Deal or No Deal. In Deal or No Deal, the configuration of the game board displaying the dollar amounts left in play is split to show the low dollar values on the left (i.e., between $0.01 and $750) and high dollar values on the right (i.e., between $1,000 and $1,000,000). During the game, the player may indeed apply this priority heuristic (at least conceptually) by considering the values remaining on the left side of the board as the minimum gain and the values remaining on the right as the maximum gain. In this respect, if the minimum gain outweighs the maximum gain (as in the comparison of the aspiration level to the difference in minimum gains), then the player should stop and take the Banker's offer. However, if the reverse occurs, then the player should reject the Banker's offer and continue to the next round. If the minimum gain appears to be equal to the maximum gain, then the player should most likely continue to the next round. These hypothetical observations would need to be confirmed based on existing game show data because there may be other factors that also influence Deal or No Deal decisions.

As was discussed in the Breadth section of this essay, Deal or No Deal players are risk seeking in the positive domain of gains (contrary to prospect theory predictions). Thus, risk is a major component of game show gambles and should be accounted for both objectively and subjectively. The priority heuristic incorporates risk through the ordering of reason and in the assignment of the probability of minimum gain. However, is this enough to account for all of the risk a player encounters during the Deal or No Deal game? Risk has been addressed in other recent studies with respect to decision making in general. For example Stewart, Chater, Stott, and Reimers (2003) considered the contextual tradeoff between risk and reward while Campbell (2005) examined risk in terms of perceived harm. Each of these studies applied their unique concept of risk to decision making in hopes of better understanding the decision making process.

Prospect Relativity

Stewart, Chater, Stott, and Reimers (2003) recognized that most decisions, whether from an economic or psychological perspective, are based on risk. In fact, Stewart et al. believed most people do not make decisions based on expected utility (as rational decision makers are expected to do), but first consider the tradeoff between risk and reward before making the decision.

Stewart et al. referred to this type of decision making as “prospect relativity” since the perception of utility for these decision makers is contextual. In other words, each prospect is considered with respect to the other prospects in the decision. To study the influence of contextual effects on decisions made under risk, Stewart et al. performed several experiments in which college students were presented with a series of decision sets of alternatives. Each decision set contained risky prospects and subjects were asked to choose from a list of certainty equivalents. A certainty equivalent represents how much money the subject would be willing to pay to play the gamble. Thus the purpose of this study was to determine if the choice of certainty equivalent was contextual in nature, resulting in prospect relativity.

After performing the first experiment, Stewart et al. (2003) found that the amount of the certainty equivalent was influenced by the amount of the gamble and the probability associated with winning that gamble. In other words, the certainty equivalent was affected by context. As a result, Stewart et al. concluded that decision makers do not form stable judgments concerning prospect value, but instead rely on the available options to guide them. In other words, decision makers learn to adjust their decisions based on the parameters of the model. This contextual approach may be the case when decisions are made under pressure or time constraints (as described by Slovic, Finucane, Peters, and MacGregor, 2004) or if the decision maker chooses to disregard more quantitative aspects of the decision. Stewart et al. tried to disprove this affect in subsequent experiments, but in each case, the results continued to support their hypothesis. Thus, risk can be affected by the context in which the decision is being made. Closely related to regret theory, prospect relativity seems somewhat intuitive. However, with respect to Deal or No Deal decisions, each round of the game presents a new situation in which the prospects can be contextually compared. Thus from a subjective point of view, prospect relativity may describe some aspects of the decision making process for Deal or No Deal decisions. Objectively, risk may be interpreted in terms of harm or benefit as Campbell (2005) did.

Risk, Harm, and Benefit

Whether assessed objectively or subjectively, risk plays a pivotal role in the rational decision making process. Indeed, associated risks and/or benefits must be assessed before a decision is made. Thus, what risk is and how it is assessed has always been an important consideration in decision theory. Recently, Campbell (2005) examined individual risk associated with an activity (i.e., alternative or action) and defined it in terms of perceived harm in order to calculate overall risk. With regard to activities, "harm" is represented by a negative utility (as in prospect theory's utility curve; Kahneman & Tversky, 1979) which can be described as the disutility, badness, loss, cost, or any other detrimental effect perceived by the decision maker (Campbell, 2005). "Benefit" then, is the opposite of harm and is represented by a positive utility. Thus, when the decision maker examines an activity, he or she first assesses the potential harm or benefit of that activity.

Mathematically, Campbell (2005) described risk in terms of an action or activity (referred to as *A*; e.g., driving a car) and the possible good, bad, or neutral outcome or consequence (*x*) of that activity (e.g., wrecking the car). Campbell assessed risk by weighting the harm of this possible outcome *x* ($h(x)$) of action *A* by the probability of outcome *x* occurring ($P(x)$).

$$Risk_x = h(x)P(x) \qquad \text{Eq 5.}$$

If activity *A* were to occur, the expected harm or risk of the outcome *x* could be calculated (with respect to *A*) as $e(h)$, incorporating both subjective and objective probabilities. A positive result would indicate that *x* is beneficial while a zero result would indicate neutrality (i.e., neither a risk nor a benefit).

Associated with an activity or alternative are the states or outcomes (s_1, s_2, ..., s_i) whose risks are found by multiplying the harm of the state ($h(s_i)$) by the probability of the state ($P(s_i)$) (Campbell, 2005).

$$Risk_{s_i} = h(s_i)P(s_i) \qquad \text{Eq 5.}$$

Similar to calculating an expected value, the overall risk of activity *A* could be found by adding together the risks associated with the states for an activity (i.e., risks are additive; Campbell, 2005). In addition to individual risks associated with a single variable, multiple variables could cause a collective harm that is different than the individual harms. In this case, Campbell suggested that not only must the individual harms be considered when assessing overall risk, but also any combined harms.

Campbell (2005) computed overall risk (if negative) or benefit (if positive) by summing the individual risks. This assessed overall risk would then be used to guide the decision maker’s choice. The assessment of overall risk can be hampered or made difficult in many ways. For example, Campbell pointed out that overall risk will be affected if possible outcomes are forgotten or ignored. In addition, the assessment of harm is still somewhat subjective and may vary from person to person thereby affecting the overall risk. Another problem that may affect risk is that the probability of *x* may be difficult to define. In addition, one decision may result in more decisions which may themselves branch out into even more future decisions resulting in the need to determine a cutoff point for analysis. Who determines the cutoff point and where the cutoff point is located will also affect the overall risk of the decision. Campbell stated that because risk is additive and as along as the laws of probability are met, risk could be assessed over this future timeline. Even with these potential problems, risk may still be quantified to aid the decision making process. For example, Steel and König (2006) approached the assessment of risk by integrating together four different decision theory models that had certain commonalities in order to devise one model that would explain the decision making process.

Temporal Motivational Theory

Steel and König (2006) presented a study in which they integrated four decision or motivation theories: (a) picoeconomics, (b) expectancy theory, (c) cumulative prospect theory, and (d) need theory. These theories were chosen because they were similar in terminology, had common sources, and could be expressed mathematically. Steel and König's logical and masterful integration of these models resulted in a multi-discipline approach to decision making over time referred to as "temporal motivational theory."

Picoeconomics describes how people change their preferences over time (i.e., preference reversal) as delay in the form of procrastination results in regret. This is also referred to as hyperbolic discounting or temporal discounting. In picoeconomics, utility (i.e., preference for an alternative) is equal to the payout of an action. This payout is based on the rate or frequency of the action payout (based on the degree of uncertainty), the amount of the payout, and the amount of delay time before receiving the payout (i.e., the longer the delay, the less utility). This basic concept is referred to as the matching law and is represented mathematically as (Steel & König, 2006):

$$Utility = \frac{(Rate)(Amount)}{Delay} \qquad \text{Eq 6.}$$

From a temporal perspective, this model is used to predict the collective behavior of decision makers when choosing from among several alternatives, each of which results in a specific reward at various times. In this equation, utility is dependent upon the variables *Rate*, *Amount*, and *Delay*, all of which are related to an alternative's reward. The variable *Rate* refers to how often the action leads to the reward (for example, purchasing stock *A* will result in a reward or gain of $*x*). This frequency is expressed as a percentage from 0% (it will never occur; e.g., the stock price will remain the same) or 100% (a certainty; e.g., the stock price will increase by $*x* with certainty). The variable *Amount* refers to the actual amount of the reward that is received (e.g., the realized gain or profit) while the variable *Delay* refers to the amount of time needed to achieve this amount (e.g., the number of days it takes to reach this profit amount). Obviously, *Utility* improves if the temporal delay is small. For example, say a consumer was considering purchasing two stocks: *A* and *B*. Using the matching law for stock *A* based on an expected profit of $1000 at a rate of 50% within a 25 day period, the utility would be calculated to be 20. Based on the same profit amount and rate but with a delay of 10 days, the utility for stock *B* would be 50. Thus, based on the maximum utility, the consumer would most likely choose to purchase stock *B*.

Starting with this basic matching law, Steel and König (2006) modified it to partially incorporate rate into delay (since rate and delay are inversely related; e.g., a low rate of 10% would require a large delay time to achieve a profit of $1000) and expanded the denominator in order to represent individual sensitivity to delay. In other words, the more sensitive an individual is to delay, the more effect that delay will have on the decision. For example, if a consumer only prefers to hold onto a stock for a short amount of time (e.g., a day trader), then they will be very sensitive to choices or purchases where a profit (i.e., amount) will not be realized for a long time (i.e., delay). The resulting formula as presented by Steel and König is:

$$Utility = \frac{Amount}{Z + \Gamma\left(T - t\right)} \qquad \text{Eq 7.}$$

where Z = immediate rewards constant or determinant of instantaneous utility

$\left(T - t\right) =$ delay of reward

where $T =$ time reward

$t =$ time now

$\Gamma =$ discounting constant (i.e., sensitivity to delay)

Note that in Eq 7 above, the input values Z and Γ are subjective and depend on the individual decision maker.

Next, Steel and König (2006) incorporated expectancy theory into the model. Expectancy theory is a form of expected utility theory that multiplies expectancy (i.e., feasibility in terms of probability of the outcome) by the value of the expected outcome ($E \times V$). The decision is based on the alternative with the largest $E \times V$ result. Although this model does not take into consideration time (as picoeconomics does), Steel and König equated “value” with “amount” and “expectancy” with “rate” in the matching law equation (see Eq 6) and thus substituted $E \times V$ in the numerator of this formula to provide a more objective view of utility. In the previous stock purchase example, expectancy would now represent the probability of obtaining a profit while value would represent that profit amount. After incorporating this, the integrated matching law equation is now represented as:

$$Utility = \frac{\text{Expectancy} \times \text{Value}}{Z + \Gamma\left(T - t\right)} \qquad \text{Eq 8.}$$

As an extension of Kahneman and Tversky's prospect theory (1979), Steel and König (2006) used cumulative prospect theory to further describe value and expectancy. In both prospect and cumulative prospect theories, the value of an outcome is expressed in terms of the loss or gain with respect to the status quo or current asset position. The resulting S-shaped value function is concave with respect to gains and convex with respect to losses. (This is similar to expectancy theory's probability curve in which the lower or overweighted probabilities are convex and higher or underweighted probabilities are concave.) What sets cumulative prospect theory apart from prospect theory is the consideration of the cumulative probability distribution and the probability weighting component. Integrating the concept of cumulative prospect theory into the previously modified matching law, Steel and König presented the equation:

$$Utility = \sum_{\mathrm{i=1}}^{\mathrm{k}} \frac{E_{CPT}^{+} \times V_{CPT}^{+}}{Z + \Gamma\left(T - t\right)} + \sum_{\mathrm{i=k+1}}^{\mathrm{n}} \frac{E_{CPT}^{-} \times V_{CPT}^{-}}{Z + \Gamma\left(T - t\right)}$$

where $E_{CPT}^{+} =$ expectancy associated with k gains

$V_{CPT}^{+} =$ perceived value associated with k gains

$E_{CPT}^{-} =$ expectancy associated with $n - k$ losses Eq 9.

$V_{CPT}^{-} =$ perceived value associated with $n - k$ losses

$\sum$ = the cumulative effects of gains and losses over multiple outcomes for any given alternative

At this point, the formulation becomes more subjective, depending on perceived values and subjective probability weightings (typically lower probabilities are overweighted while higher probabilities are underweighted; Steel & König, 2006). Each of these values would have to be assessed based on individual preferences, resulting in variability among decision makers (such as stock investors). However, the resulting utility function closely follows prospect theory's "S"-shaped curve; that is, risk averse in the positive domain of gains (e.g., stock investors would perhaps delay purchasing a stock that is increasing in value in hopes that the price would level off) and risk seeking in the negative domain of losses(e.g., stock investors would perhaps risk purchasing a stock that is decreasing in value in hopes that the price would increase soon).

Steel and König (2006) further refined Eq 9 by integrating a fourth theory: need theory. Need theory describes a system of needs that behaviorally influence actions and result in satiation (i.e., the release of the need). In this model, “needs” are the driving force behind actions with the intensity of the need dictating the necessity and order of action. Needs (and their associated intensity) change constantly as the environment (i.e., expectancy and time delay) changes resulting in strongly influential external cues called “press.” For example, with respect to the stock purchase example, an influential press might be the investor’s retirement status. If the investor is close to retirement, he or she will have greater need to make more profit and thus necessitate riskier investments. Steel and König believed that need intensity was equivalent to utility in that seeking an action that would satisfy the strongest need was akin to seeking an action that would provide the highest utility. Steel and König also believed that needs played a part in determining the value of an action. Thus the sensitivity to delay represented by the discounting constant Γ, would change depending on the need and the resulting value with respect to whether it is a gain or loss. With this in mind, Steel and König added a final modification to their temporal motivational theory formula:

$$Utility = \sum_{i=1}^{k} \frac{E_{CPT}^{+} \times V_{CPT}^{+}}{Z + \Gamma^{+}\left(T - t\right)} + \sum_{i=k+1}^{n} \frac{E_{CPT}^{-} \times V_{CPT}^{-}}{Z + \Gamma^{-}\left(T - t\right)} \qquad \text{Eq 10.}$$

where $\Gamma^{+} =$ discount for gains

$\Gamma^{-} =$ discount for losses

Based on this formula, Steel and König's temporal motivational theory predicted decision making behaviors based on expectancy, value, time (in terms of delay), and gains and losses. Thus, as Steel and König had hoped, the temporal motivational theory model integrated four decision theories (i.e., picoeconomics, expectancy theory, cumulative prospect theory, and need theory) through these components.

Steel and König described various uses for their model, however temporal motivational theory is not a parsimonious model and is intimidating and non-intuitive for the everyday decision maker. Additionally, it is possible that decision makers are not even capable of processing the input values or evaluating probabilities. Peters, Vastfjall, Slovic, Mertz, Mazzocco, and Dickert (2006) examined this effect that they termed "numeracy" on the decision making process while Slovic, Finucane, Peters, and MacGregor (2004) examined risk from the simplistic and subjective point of view of affects.

The Affect Heuristic

When faced with a decision (especially in the case of a gamble such as on Deal or No Deal), individuals consciously or subconsciously assess the risk involved before making the decision. This assessment can take place either objectively based on numbers (Campbell, 2005; Novemsky & Kahneman, 2005; Steel & König, 2006; Brandstatter, Gigerenzer, & Hertwig, 2006) or subjectively. Slovic, Finucane, Peters, and MacGregor (2004) referred to this subjective assessment of risk based on feelings as "affects." In a study by Slovic et al. (as well as in subsequent studies by Slovic, Peters, Finucane, and MacGregor, 2005, and Slovic and Peters, 2006), risk was evaluated based on subtle affects—past experiences, emotions, and beliefs which formulate images that are recalled depending on the circumstance.

In trying to understand and explain the decision making process, Slovic et al. (2004) studied the analytic and experiential systems of thought (also referred to as deliberative and affective-experiential; Peters, Vastfjall, Slovic, Mertz, Mazzocco, & Dickert, 2006). In the experiential system, thinking (and decision making) is influenced by experiences, emotions, beliefs, associations, and images, all of which are rapidly processed so that the decision maker can quickly react. Whether the decision maker is even aware of these subtle "affects" or not, he or she often relies on them to make decisions (Slovic et al. referred to this as the "affect heuristic"). Conversely, decision making as described by the analytic system is influenced by logic, conscious appraisal, abstract symbols or numbers, and concrete evidence (i.e., reason), all of which are slowly processed resulting in delayed reactions or decisions based on reason. Slovic et al. believed that affect is needed for rational decision making, so while these two systems of thought seem to be diametrically opposed, in reality, the decision maker utilizes both affect and reason simultaneously.

As individuals experience life, they evaluate the positive and/or negative effects of the experience in terms of the relative affective salience of the information (Slovic et al., 2005). When prompted by the necessity to evaluate risk, these stored salient qualities induce images which are tagged with affect. An affect pool then, contains all of the positive or negative tags that are associated with each of these images. Slovic et al. (2004) defined the affect heuristic as an intuitive process of evaluating, mapping, and pooling this affective information and images (i.e., affective impression) which can then be drawn from to assess risk and ultimately make decisions. Thus, when making easy or even complex decisions, the decision maker relies on this affect pool to guide them because the affect heuristic is quick, easy, and readily available. The affect heuristic can be applied as illustrated in Figure 3.

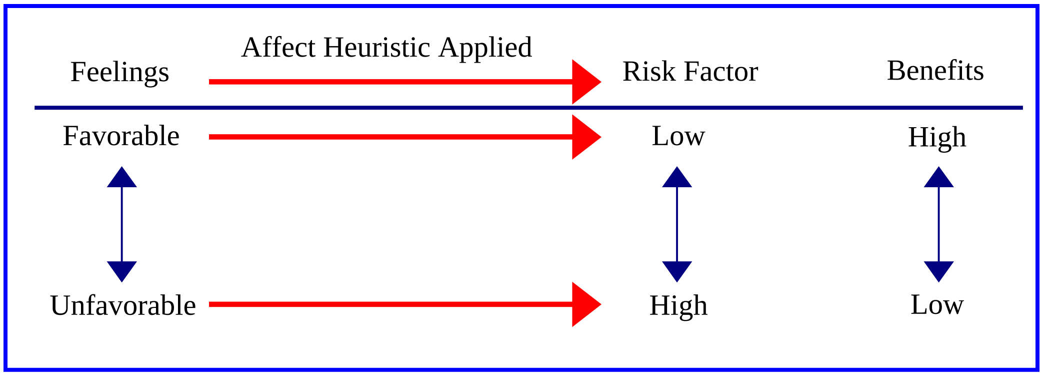


Figure 3. The Effect of the "Affect Heuristic" on Perceived Risks and Benefits in Decision Making (Slovic, Finucane, Peters, & MacGregor, 2004)

The above Figure shows that the perception of both the potential risks and benefits of a decision are influenced by the affect heuristic and can ultimately and directly affect the outcome. However, Slovic et al. (2004) pointed out other research studies which showed that the affect heuristic itself can be influenced by time and information constraints which then directly affect the decision. Additionally, how information is presented to a decision maker can also influence the affect heuristic. For example, when information is presented merely as facts (such as probabilities), the potential risks and benefits are perceived differently than when the information is presented with imagery or narratives (such as relative frequencies) that induce affective feelings. If the affect heuristic is used during Deal or No Deal decisions, it is likely that the presentation of the Banker's offer as well as the player's chances of winning will greatly influence the affect heuristic.

Slovic et al. (2004) also pointed out that just as the affect heuristic can be used to guide the decision making process, it can also be used to mislead decision making through deliberate manipulation of feelings. For example, this occurs during Deal or No Deal when the player is reminded of their need for money and what winning would do to change their lives or when the Banker purposely tries to psychologically intimidate the player. It also occurs through the decision maker's own inherent biases and fears. In addition, affects are insensitive to probabilities (referred to as probability neglect; Slovic & Peters, 2006). For example, the decision maker will focus on the bad outcome and ignore the small likelihood of that outcome happening. Focusing on affects will also result in insensitivity to numbers which is reflective of prospect theory's utility curve. However, even with these possible weaknesses, the affect heuristic is still a viable model that can be used along with quantitative reasoning to aid the decision making process. It is this approach that Peters, Vastfjall, Slovic, Mertz, Mazzocco, and Dickert (2006) took in their examination of decision making.

Numeracy and Attribute Framing

There are two kinds of decision makers: those that understand and are able to use numbers (i.e., numeracy) and probabilities and those that are not. As a result, decision makers, who do not use numeracy, typically resort to using attribute framing. Attribute framing refers to how the decision maker perceives the attribute based on the available information. This available information can be manipulated by individuals or marketers in order to sway the decision maker's perception of that attribute. However, the use of logic and numeracy in the decision making process may guard against the effects of attribute framing. Peters, Vastfjall, Slovic, Mertz, Mazzocco, and Dickert (2006) were concerned with the decision maker's ability to process numbers and evaluate probabilities (i.e., numeracy). Thus Peters et al. postulated that decision makers who were able to use numeracy in the decision making process would not be influenced by attribute framing (and perhaps affects as well).

To evaluate this hypothesis, Peters et al. performed an experiment in which the participant's ability to use numeracy was first assessed. Participants were then asked to rate a series of student exam scores. In order to test for attribute framing, the exam scores were presented either as percent correct (i.e., positive frame) or percent wrong (i.e., negative frame). Peters et al. found that those participants who fell into the low-numeracy category rated the positive frame more highly than the negative frame while the high-numeracy group was able to make the transformation in ratings from frame to frame. In other words, attribute framing did influence individuals who were not able to understand or process numerical probabilities of events.

In a second experiment, Peters et al. tested whether a participant's ability to transpose numbers from frequencies to percentages would affect their perception of risk. Peters et al. found that low-numeracy students were not able to make the connection between frequencies and percentages and may have been influenced by affects (i.e., stored images and other emotions; Slovic, Finucane, Peters, & MacGregor, 2004) closely associated with frequencies. As a result, Peters et al. next investigated whether thought processes (i.e., deliberative and affective-experiential) were affected in any way by numeracy.

Thought processes can be described as being deliberative (i.e., logical, slow, deliberate, conscious thought on a higher level) or affective-experiential (i.e., automatic, perhaps sub-conscious, emotional thought that often results in quick action based on affective associations). Slovic, Finucane, Peters, and MacGregor, (2004) referred to these systems or modes of thought as analytic and experiential. In this study Peters et al. tested the interaction between numeracy and affect using comparisons between frequencies and probabilities. In addition, the authors examined both affect (i.e., perceived feelings and emotions) and affective precision (i.e., clarity of expressing the feelings). Peters et al. hypothesized that high-numeracy individuals would first use the deliberative mode to determine and compare probabilities before incorporating affects into the decision while a low-numeracy individual would instead rely on the affective-experiential mode and most likely make the decision based on frequencies. In fact, Peters et al. found that low-numeracy individuals made sub-optimal choices and had less affective precision than high-numeracy individuals.

Peters et al. next examined whether high-numeracy individuals made less rational choices as a result of their reliance on the deliberative mode of thinking. To examine this, Peters et al. presented the following gambles and asked the participants to rate the attractiveness of the bets as well as their affect and affective precision for both gambles.

$$A:\left(\$9, 7/36; \$0, 29/36\right)$$

and

$$B:\left(\$9, 7/36; -\$.05, 29/36\right)$$

Although gamble *A* is the better bet, high-numeracy participants rated this gamble as less attractive than gamble *B* while low-numeracy individuals rated both gambles as equally attractive. The results also showed that high-numeracy participants were able to obtain more precise affective meaning from number comparisons and probabilities than low-numeracy participants. As a result of these studies, the authors concluded that numeracy does affect the decision making process. In addition, high-numeracy individuals are able to better utilize affects to provide more precise affective meaning when making decisions. This study seems applicable to players on the game show Deal or No Deal. It is obvious that those players who do not appear to have numeracy often make poor decisions. Players with numeracy are able to take into account both the probabilities as well as affects and thus make better, more educated decisions. Unfortunately, it would be difficult to prove this without first testing each player’s numeric abilities.

Timesaving Decisions

Time, or the lack thereof, can have a huge impact on decisions. In fact, Steel and König (2006) tried to incorporate time (with respect to delay) as a factor in their proposed temporal motivational theory. In this study, Munichor, Erev, and Lotem (2006) examined attitudes concerning risk (i.e., risk seeking or risk averse) and their impact on small, timesaving, monetary-based decisions. Timesaving decisions involve one alternative that is a short-cut and will save a small amount of time (e.g., seconds or milliseconds) only if the outcome is successful. If the outcome fails, then the choice to use the shortcut was a bad one that could result in more time spent on the task. In any case, the decision is one with which the participant is familiar and has had to make before. Thus, the choice is based on experience.

In order to study the effects of time-delayed monetary-based decisions, Munichor et al. (2006) performed a series of experiments in which participants were presented with risky choices which were associated with certain time delays. The final monetary outcome depended on their choice over repeated trials. In one experiment, participants were presented with two buttons on a computer screen and asked to select one. Each button represented one of the problem set alternatives and the delay time was represented by a red light around the button that would stay on for the designated time (either a fixed or variable amount of time according to the probability distribution of the alternative). By choosing a button, the participant was choosing either a safe (i.e., short delay time) or risky (i.e., long delay time) choice.

In the first experiment, no matter which button was chosen, the light around each button would stay on for the designated fixed delay time. The observed light around the unselected button represented the foregone payoff. The participants performed the task of choosing a button 100 times during which they most likely learned from the previous experiences. Through this experiment, Munichor et al. (2006) showed that risk aversion occurred since the majority of participants chose the shorter delay time (i.e., the safe choice). In a similar problem with variable delays, participants also preferred the shorter delay time. However, this behavior was construed as risk seeking because participants were taking chances each time they chose the variable time button. Munichor et al. associated this with the inclination to underweight rare events.

In another experiment involving a gamble with fixed time intervals, Munichor et al. (2006) provided feedback in the form of a light only for the selected button. The unselected button remained unlit so as to reduce noise and eliminate a comparison of delay times. In this case, removal of the foregone payoff feedback for the unselected button resulted in random selections. Munichor et al. attributed this result to perceived variability in delay time which was not overcome by experience as the participant worked through the 100 trials.

Natural timesaving decisions, in which time is considered to be the currency, were evaluated in another experiment by Munichor et al. (2006). In this experiment, participants were encouraged to complete the experiment as quickly as possible. As a result, loss was interpreted in terms of time (seconds). After presenting the participants with a gamble, they were instructed to select one of two colored paths which represented the problem alternatives. Once selected, the path revealed squares (the number of which was determined by the alternative's outcome) and the participant would press a key the same number of times as there were squares. Once at the end of the path, a new trial would begin for 100 trials. Again, the goal was to complete the task in a minimum amount of time. The results indicated a preference for the alternative that lead to the best outcome (i.e., shortest path). In addition, Munichor et al. observed that risk seeking decreased with time.

As a result of these experiments, Munichor et al. (2006) concluded that when participants can reliably rank the outcomes, they will prefer the alternative that gives the best outcome, regardless of whether it is risk seeking or risk averse. This finding tends to support the priority heuristic's ordering scheme described by Brandstatter, Gigerenzer, and Hertwig (2006). When reliable ranking of outcomes is not possible, the decision maker resorts to random choice. In addition, upon repeated trials, a learning curve takes place which results in less risk seeking behavior over time. This concept is interesting because the game show Deal or No Deal could be thought of as repeated trials (i.e., each round represents a trial) but with different alternatives and outcomes each time. It would be interesting to determine if there is a learning curve in the Deal or No Deal decision making process similar to that shown by Munichor et al.

Format and the Lemon Avoidance Heuristic

Prospect theory (Kahneman & Tversky, 1979) showed that decision makers were risk averse when choices were based on gains. The conclusion often drawn from this is that decision makers will choose to avoid a loss when the loss looms larger than the gain. However, recent research reported by Ert and Erev (in press) has revealed contradictions in this finding with respect to mixed gambles (i.e., gambles representing both gains and losses) and the status quo. The status quo is represented by a $0 gain or loss. Thus, Ert and Erev chose to study this contradiction with respect to the context in which the gamble is presented. To document this effect, Ert and Erev conducted a series of experiments under varying conditions.

The first condition tested what Ert and Erev (in press) called the "format hypothesis" due to the two formats or conditions in which the two gambles were presented. For example, in this experiment, half of the participants were asked to choose among the following alternatives:

$$A:(\$0)$$
$$B:(\$2,000, 0.5; -\$500, 0.5)$$

The majority (78%) of the respondents chose the risky alternative *B* under this format of comparing a gamble with a high expected value (i.e., EV=$1,500) to the status quo (i.e., EV=$0). However, when the other half of the participants were given only alternative *B* and asked to either accept or reject the gamble, a smaller majority (55%) agreed to accept the gamble. Although the status quo was implied in the second group, framing the decision without the explicitly-stated status quo did affect the decision.

Because the above experiment was performed in a structured setting (another format of sorts that could affect the decision), Ert and Erev (in press) took the above experiment out of the physical classroom in order to see if decision makers utilize a "lemon avoidance heuristic" when the decision was presented by a stranger. Under the lemon avoidance heuristic, decision makers would be wary of taking on a mixed gamble because its features would be suspicious. In this case, an experimenter (a stranger) went up to the participants in the hallway of the school and presented the mixed gamble either with the status quo alternative or without. Under these conditions, 51% of participants chose the gamble in the choice group (i.e., with the status quo) while only 42% chose the gamble in the accept/reject group. This trend indicated that decision makers will shy away from a risk when it is presented by an unknown person in an unstructured setting (e.g., a hallway). However, it could also be indicative of indifference which would result in random responses.

In order to prove or disprove indifference, Ert and Erev (in press) performed an experiment similar to the previous experiment except that in this case, the expected values were equal. They hypothesized that if the responses were truly random, then the proportion of participants choosing either format gamble would be statistically insignificant. The results indicated a rejection of the indifference hypothesis and support for the hypothesis of the lemon avoidance heuristic. In other words, participants tended to choose a gamble based on the attractiveness of that gamble and not simply due to random behavior.

As a result of these experiments, Ert and Erev (in press) concluded that the inclusion of the status quo in the decision set did affect risk aversion in a mixed gamble. In addition, the lemon avoidance heuristic comes into play when decisions can be viewed as tricky or suspicious (i.e., lemons) and will result in risk aversion. When used in conjunction with the format affect, rejection of the offer (i.e., risk aversion) occurs more frequently. Indifference did not play a role in this case and so the decision making behavior could not be blamed on random behavior.

Decisions made during the game show Deal or No Deal do not follow prospect theory's risk aversion findings. In fact, Deal or No Deal players are typically risk averse in the positive domain. However, the idea of applying the format hypothesis and lemon avoidance heuristic to the Banker's offer could have merit. If the offer is formatted or framed correctly and the lemon avoidance heuristic is applied, it may result in more risk aversion and thus higher acceptance of the Banker's offer earlier in the game. As a result, the Banker wins because the player will exit the game with the least amount of winnings.

Theory of Intrapersonal Games

Another new decision theory is the theory of intrapersonal games or TIG (Ding, 2007). This theory seeks to explain decisions based on quantifiable psychological factors. The conceptual framework as presented by Ding classifies agents (i.e., unique entities within the mind) into four types according to the following scheme in Figure 4 (p. 3):

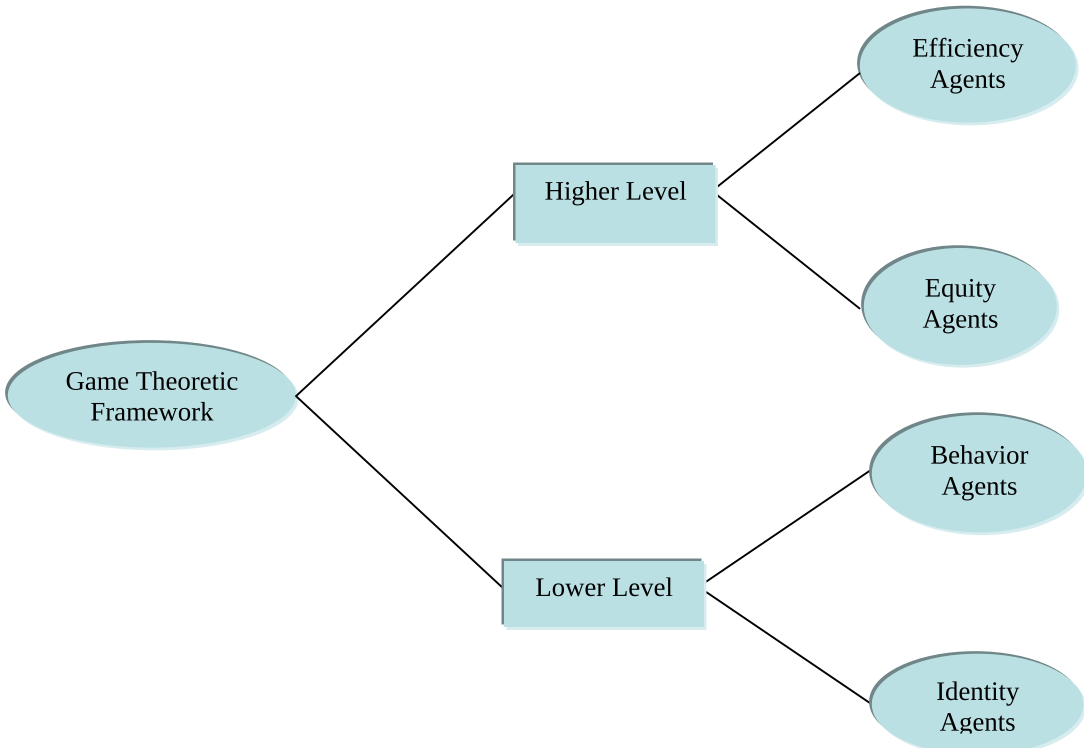


Figure 4. Conceptual Framework for the Theory of Intraperson Games (Ding, 2007)

In this classification scheme, Ding (2007) described behavioral agents as actions which the decision maker might take; being responsible for implementing specific actions; without utilities; and mirroring actions defined in standard game theory. Identity agents represent unique individual preferences; with utilities; but not modeled in standard game theory. These two lower level agents play the role of strategies in the TIG model while the higher level agents (i.e., efficiency and equity) act as the players. Slovic, Finucane, Peters, and MacGregor, (2004) referred to the higher level agents as deliberative or analytical thought process and the lower level agents as affective-experiential thought processes. According to Ding, efficiency agents represent the control behavior that makes the conscious choices concerning the behavior agents. Acting at the conscious level, efficiency agents seek to maximize overall utility from the identity agents. On the other hand, equity agents represent the control which selects the appropriate identity agent for that particular circumstance and distributes utilities to it. Equity agents work on both a conscious and subconscious level along with (and perhaps contrary to) the efficiency agent to guide the decision maker. Thus decisions may entail compromises or tradeoffs between efficiency agents and equity agents.

Thus, based on this conceptual framework, Ding (2007) proposed the following TIG strategy as illustrate in Table 3 (p. 5):

Table 3. The TIG Model Strategy as Outlined by Ding (2007)			
Player	Pure Strategy	Mixed Strategy	Payoffs
Efficiency Agent	$S_b = \left\{ s_b^1, ..., s_b^B \right\}$ where *b* represents the behavior agent.	$\Sigma_b = \left\{ \sigma_b^1, ..., \sigma_b^B \right\}$ a prob. dist. over S_b	Behavioral agent: None Efficiency agent: $\sum_{m=1}^{I} \sum_{n=1}^{B} \sigma_i^m \sigma_b^n u^m \left(s_b^n \right)$
Equity Agent	$S_i = \left\{ s_i^1, ..., s_i^I \right\}$ where *i* represents the identity agent.	$\Sigma_i = \left\{ \sigma_i^1, ..., \sigma_i^I \right\}$ a prob. dist. over S_i	Identity agent (*m*): Not selected: 0 Selected: $u_m \left(s_b^n \right)$ for strategy $\left(s_b^n \right)$ Equity Agent: $f\left(\sum_b, \sum_i, u^1 \left[s_b^1 \right], ..., u^1 \left[s_b^B \right], ..., u^I \left[s_b^1 \right], ..., u^I \left[s_b^B \right] \right)$

With respect to the game strategy, Ding (2007) claimed that at least one Nash equilibrium (which could involve mixed strategies) may be reached and the optimal strategy may be obtained in one of the following ways: (a) through strategic thinking via an efficiency agent, or (b) via the equity agent either through strategic thinking, simple heuristics, or mutation and selection (i.e., evolution). Ding illustrated the TIG model using a small empirical study in which two variety-seeking cases (i.e., what to eat for lunch and what type of video to watch), two identity agents (i.e., healthy food versus food that tastes good and fun/relaxation versus emotionally uplifting movies), and two types of behavior choices (i.e., salad versus hamburger and comedy/action versus emotional videos) were evaluated. The results showed that the TIG model was robust and did adequately evaluate variety seeking behaviors among the participants (Ding, 2007).

The psychological agents presented in this study encompass all aspects of the human mind (i.e., id, ego, and superego) in the decision making process. In that respect, this model takes a novel approach at decision making. However, there still seems to be some overlap with other decision models that take into account feelings such as regret (i.e., regret theory) and other emotions referred to as affects (i.e., affect heuristic). Perhaps the TIG model could be applied to Deal or No Deal decisions. However, a simpler explanation of this decision making behavior would be preferred.

Conclusion

Over the last hundred years, psychologists and economists have been searching for a decision theory that would adequately model human decision making behavior. However, decisions are influenced not only by the surrounding environment, but also by risk, harm, affects, priorities, utility, logic, and probabilities to name a few. Additionally, many of these factors can influence the decision maker either consciously, subconsciously, or both and can be expressed objectively or subjectively. Many of the proposed decision theory models are based on the same foundational structure—Bernoulli's expected utility—while others deviate towards simpler heuristic based models. In addition, some decisions may be influenced by (or even adequately resolved by) the use of conditional probabilities such as Bayesian inferential statistics. Although Bayes Theory was not addressed in this essay, it should not be excluded from any future study of decision theory. Regardless of the foundation, each model has bounds and limitations that must be taken into account. Thus, any attempt to explain all decision making behavior under one model would be a futile effort.

Decision theory is analogous to a large puzzle (i.e., human decision making behavior) and each piece (i.e., individual model) contributes to the overall picture. So, rather than trying to solve the entire puzzle at once, scientists have simply approached it one problem at a time and one model at a time. This is the case with decisions made during the television game show Deal or No Deal. The conditions surrounding these decisions are unique to the individual and their circumstances and thus each case must be examined carefully. In fact, because of time constraints, emotional pressures, and mathematical abilities to name a few, it may be difficult for many of the Deal or No Deal players to actually utilize many of these models while playing the game. However, some of the simpler heuristic models may be used intuitively by the players to help them make decisions. Thus, while many of the models presented here have merit with regard to this game show's strategy, empirical evidence needs to be provided before a specific theory may be adopted. Thus, in the Application component of this essay, data collected over the first two seasons of the American version of the game show Deal or No Deal will be analyzed and evaluated to see which model (if any) is the best predictor of these decisions.

APPLICATION

SBSF 8231: PROFESSIONAL PRACTICE IN HUMAN DEVELOPMENT—APPLIED DECISION ANALYSIS

Introduction

What do you get when you cross a logical, mathematically-based gamble with a nervous, emotionally charged, decision maker under time constraints? You get a quick decision that is based on logic and probabilities but is strongly influenced by emotion and regret. That concisely describes a Deal or No Deal decision. In the popular American version of the television game show, players are asked to choose between taking the Banker's offer (a certain monetary gain) or continuing to the next round of play (a risk). Although this may sound like an easy choice, this decision must be made in a matter of minutes with much extraneous noise and excitement from the audience and supporters, constant reminders of the player's need for money from the host, and ridicule and intimidation from the Banker. With all the excitement, noise, and distraction, what factors affect the Deal or No Deal decision? How does risk influence the player's choice? Are there differences between the American version of the game and the game in other countries? These are some of the questions that will be addressed in this essay on decision theory.

The game show Deal or No Deal originated in Holland in 2001 (History of Deal and No Deal, 2007) and since then has spread around the world, landing in America on December 19, 2005 (Deal or No Deal: About, n.d.). The rules of Deal or No Deal vary from country to country and even season to season. However, this study will examine the game show based on rules used during the first two seasons. These rules are summarized below.

Rules of the Game

For the purposes of this study, only the rules of the early American version of Deal or No Deal are considered (i.e., from the first two seasons). The goal of this game is to win the $1,000,000 prize that is randomly hidden in one of 26 cases by a third party and none on the show (including the Banker and host) know which case contains the million dollar prize. The remaining 25 cases contain varying prize amounts ranging from $0.01 to $750,000 (see Table 4; this table is the same as Table 1 in the Breadth section but is repeated here for easy reference).

Table 4. Prize Amounts Offered in Deal or No Deal

$ 0.01	$ 1,000.00
1.00	5,000.00
5.00	10,000.00
10.00	25,000.00
25.00	50,000.00
50.00	75,000.00
75.00	100,000.00
100.00	200,000.00
200.00	300,000.00
300.00	400,000.00
400.00	500,000.00
500.00	750,000.00
750.00	1,000,000.00

To begin, the player randomly selects one case containing an unknown amount of money from 26 such cases. This single case is removed from play and not revealed (i.e., opened) until the end of the game. Once this initial case is chosen, the player next chooses a specified number of cases to open depending on the round (see Table 5).

Table 5. Number of Cases Opened in Each Round

Number of cases at beginning of game: 26

Pre-round: Player randomly selects one case which remains unopened until the end of the game.

Remaining cases to choose from: 25

Round	Open	Remaining
1	6	19
2	5	14
3	4	10
4	3	7
5	2	5
6	1	4
7	1	3
8	1	2
9	1	1
10	1 and initial case	0

The player may opt out of the game during any round by simply accepting the Banker’s offer. However, if the player stays in the game until the last round, then the originally chosen case is opened to reveal their monetary prize.

The goal of the “Banker” is to entice the player to exit the game with as little cash prize as possible. To ensure this, after each round the Banker makes a monetary offer based on the expected value of the dollar amounts remaining in play (Andersen, Harrison, Lau, & Rutstrom, 2006). For example, during the first round, a player randomly chooses six cases that when opened reveal the following dollar amounts: $1, $25,000, $5, $200, $10, and $400,000. The expected value of the remaining prize amounts left in play was $149,660 and the Banker’s offer was $15,000 (on average 18% of the expected value for the first round). Based on this offer, the player now must either choose to accept it (i.e., “Deal”), thus ending the game, or refuse it to continue the game (i.e., “No Deal”). Obviously, the Banker’s offer during the first few rounds of play are purposefully low so as to keep the player in the game, however, the offer increases substantially in subsequent rounds, making the decision more difficult. The Banker tries to psychologically intimidate the player into taking the deal, especially if the player is doing well in the game, by remaining anonymous and partially hidden from view in order to appear menacing.. In addition to cash, the Banker’s offer may include incentives such as a new car, season tickets to a major football team, etc. For the purpose of this study, the cash value of the incentive is reported as the offer.

Although the player alone must make the decision to accept or reject the Banker’s offer, the audience is encouraged to voice their opinion and the host often reminds the player of their need and/or desire for the money. In addition, after opening the cases in round two, the player’s supporters (typically three family members, close friends, or coworkers) are introduced and are encouraged to talk over the decision with the player. These distractions, in addition to the Banker's intimidation efforts, contribute to the noise surrounding the decision making process for this game show. However, the main focus of this essay will be on the player's decision, regardless of the distractions.

Literature Review

When faced with a decision under time constraints, decision makers have the choice of carefully and reasonably examining the alternatives before making the decision or using simple heuristics to quickly assess and decide (Payne, Bettman, & Luce, 1996). Which strategy the decision maker uses depends on the circumstances. In addition, each of these strategies can result in distinctly different decisions. McMackin and Slovic (2000) performed a study to determine whether decision making would be affected by conscious thought prior to making the decision. In other words, would conscious and deliberate thought about the decision's reasons, alternatives, or outcomes result in a better or worse decision? McMackin and Slovic found that when decisions involved intuitive tasks, better decisions were made when decision makers did not consciously think about the reasons behind the decisions. However, in the case of analytical tasks, McMacking and Slovic found that conscious thought about the reasons in a decision resulted in better decisions. During the game show Deal or No Deal, players often make the decision to take the deal or not based on intuition mixed with excitement and emotion, often leading to a wrong decision. Since Deal or No Deal decisions are primarily analytical, rationalizing the choice could help the player make a better decision. To this end, many studies have been undertaken to examine the various versions of Deal or No Deal in order to characterize the game and the player's decision making process.

In a recent study, de Roos and Sarafidis (2006) examined data from 399 contestants in the Australian version of the game show. de Roos and Sarafidis characterized this version of the game as a high stakes game of decisions under risk but where no skill is involved. Focusing on risk averse behavior among the contestants, de Roos and Sarafidis showed that there was considerable heterogeneity (i.e., dispersion among players) when comparing risk bounds and that preferences for risk depended on whether the contestants were forward looking (i.e., thinking ahead to consider future dynamic offers from the Banker) or myopic (i.e., maintaining a static point of view concerning the offers). de Roos and Sarafidis also discounted any influence from the endowment effect for the average Deal or No Deal player. In an effort to measure risk, de Roos and Sarafidis found that more than 1/4 of their sample showed risk seeking behavior.

In another study of the Australian version of Deal or No Deal, Mulino, Sheelings, Brooks, and Faff (2006) confirmed the findings of de Roos and Sarafidis (2006) concerning the heterogeneity in risk aversion. However, Mulino et al. took this finding one step further and linked the heterogeneity to age and gender. In addition, the authors found that a player is more likely to accept the Banker's offer as it increases in value and that measures of regret were not significant factors affecting the player's decisions. Mulino et al. made an assumption that the player compares the banker's offer with the chances of winning the values remaining in play. They referred to this as myopic decision making. Thus, a myopic player would not take into account the fact that the banker's offer changes dynamically depending on the cases left in play and in fact, tends to increase as the game continues. A forward-looking player realizes this dynamic situation with the banker's offer and is able to look ahead to see what the possible outcomes could be.

Andersen et al. (2006) considered the United Kingdom version of Deal or No Deal to be a game of "dynamic choice under uncertainty in a controlled manner with substantial stakes" (p. 1). Referring to this game as a natural experiment in which the choices change dynamically but the tasks are repeatable from player to player, Andersen et al. examined the choice behavior of 211 players using expected utility theory and some of its variants. The authors found that expected utility worked best when the utility measurement included not only the cash amount of the prize but also some measure of income. Some of these considerations will be examined using data from the first two seasons of the American version of the game show.

Discussion

Demographics and Gender Differences

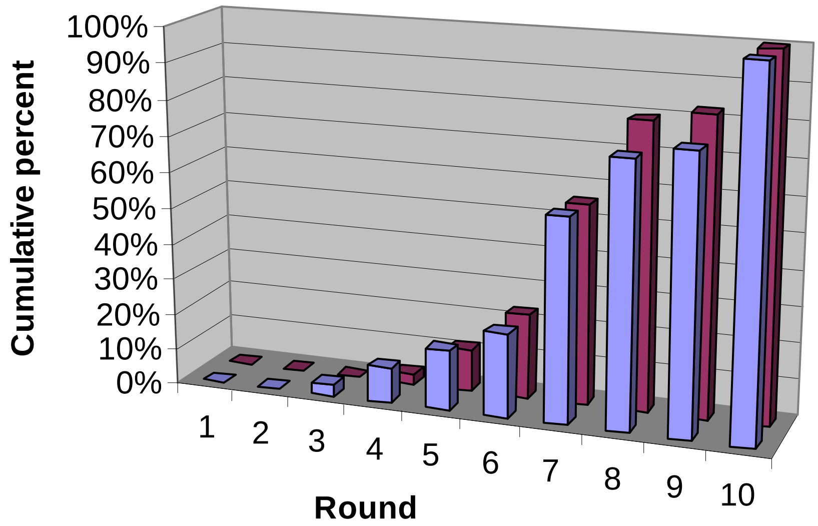
For this study, the games of 64 players from the first two seasons of the American version of Deal or No Deal were recorded. Although exact ages were not given, players ranged in age from young to old (say, 20 to 70 years). Not every player gave their occupation, but for those that did, occupations included a mix of white and blue collar jobs, students, military, and even unemployed. The distribution of male to female players is given in Table 6 below.

Table 6. Gender Distribution of Deal or No Deal Players		
Gender	n	%
Male	30	47%
Female	34	53%
Total	64	100%

Each Deal or No Deal player was specifically chosen to be on the show by the show producers and each player typically had a deep desire or need to win a large amount of money. For example, one player wanted to buy a house for his family; another had been displaced by hurricane Katrina and therefore had a desire to win a large amount of money in order to rebuild her life, etc. The show's host (Howie Mandel) often reminded the player of their desire and/or need while they were deliberating the decision. This could have had an effect on the decision in the form of regret (as discussed in the Breadth component of this essay). Although regret is difficult to measure simply through observation, the nature of this game would lead to the assumption that regret does play a role in this decision making process (although Mulino et al., [2006] ruled against this in the Australian version of the game). For example, if in the current round, the player opens some high dollar cases thus reducing the amount of the Banker's offer in the current round, then the player would most likely experience regret for not taking the previous offer from the Banker. Thus, when assessing the current offer, their feelings of regret would most likely influence their decision to either end the game (i.e., Deal) or continue to the next round (i.e., No Deal).

Depending on the player's aversion to risk, feelings of regret may cause the player to take the next offer from the Banker in order to end the game and avoid further risk. However, more risk seeking players will refuse the deal and continue to play, even perhaps, to their detriment. Thus, exactly how these feelings of regret affect a player depends on the individual and their current asset position (Bell, 1982; Loomes & Sugden, 1982, 1983) which drives their desires. In addition, whether influenced by regret or assessed intuitively or analytically, risk plays an important role in rationalizing decisions (McMackin & Slovic, 2000).

Contrary to decisions made under the premise of prospect theory, on the whole, Deal or No Deal players appear to be risk seeking rather than risk averse when presented with the chance to win large amounts of money (e.g., $1,000,000). Thus, how much risk the player is willing to take may be influenced in part by regret but also in part by gender. Past research has shown that the willingness to take risks is different for men and women. In fact, when it comes to investing money, women tend to be more risk averse than men, even after controlling for age and income level (Watson & McNaughton, 2007) as well as education and political orientation (Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000). This difference in risk behavior due to gender in Deal or No Deal decisions is illustrated in Figure 5 below.



	1	2	3	4	5	6	7	8	9	10
Males	0%	0%	3%	10%	17%	23%	57%	73%	77%	100%
Females	0%	0%	0%	3%	12%	24%	56%	79%	82%	100%

Figure 5. Cumulative Percent of Players “Taking the Deal” in Specified Round by Gender

Interestingly, none of the players accepted the Banker’s offer in the first two rounds of the game. This was most likely due to the extremely low offers. By round six, only 23% of the male players and 24% of the female players had taken the Banker’s offer and ended the game. However, by round eight, more women (79%) than men (73%) had exited the game. At round nine, 82% of the female players had already taken the deal as compared to 77% of the men. Thus 23% of the male players stayed in the game until the very end (round ten) while only 18% of the females made it to round 10. Since more female players than male players chose to take the Banker’s offer and end the game before reaching the final round, this indicates that the female players were more risk averse than the male players. This conservative behavior among female players paid off in that the average winnings for women were significantly higher than that for men ($p = .03$, see Table 7 and Figure 7 below).

Table 7. Average Winnings by Gender Over All Rounds

n	Gender	Average Winnings	Standard Deviation	Minimum Winnings	Maximum Winnings	Median Winnings
34	Female	$108,731.35	$101,468.35	$ 1.00	$402,000.00	$83,000.00
30	Male	$ 63,434.83	$ 56,042.84	$ 10.00	$214,000.00	$61,500.00
64	Overall	$ 87,498.61	$ 85,778.01	$ 1.00	$402,000.00	$73,350.00

When averaged over all rounds, female players almost doubled their winnings over the male players (Table 7). A *t* test for the hypothesis of equal means ($H_0 : \mu_{Males} = \mu_{Females}$) was performed assuming unequal variances ($p(F \leq f) = .0008$). At the $\alpha = .05$ significance level, the results showed that there was a significant difference between the average amount of money won by males versus females ($p = .03$). This difference is obvious when the amount won by round is illustrated in Figure 8. Whereas the male players out win the female players in rounds three, four, and five, this trend is clearly reversed in rounds six through nine where the largest amounts are won.

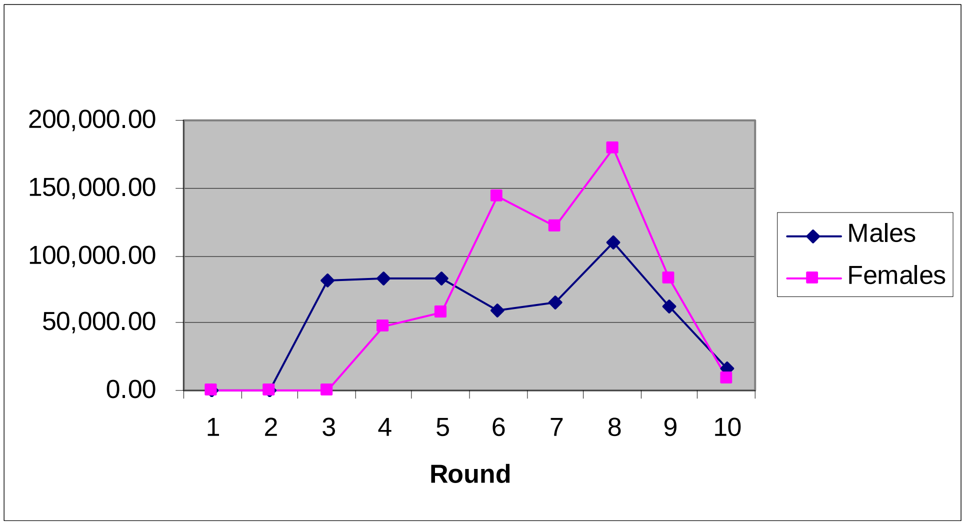


Figure 6. Average Winnings by Gender for Each Round

Figures 5 and 6 show that regardless of gender, none of the players accepted the Banker's offer in rounds one or two. This is because the Banker's offer during these two rounds is generally very low so as to entice the player to continue the game, thus promoting risk seeking behavior. However, as the game continues, more and more players choose to accept the Banker's offer and end the game. This is especially evident in round seven among both men and women. In the final round (round ten), only six female players and seven male players out of the 64 players studied remained in the game. Interestingly, a similar trend in the acceptance of the Banker's offer for the first nine rounds was observed by de Roos and Sarafidis (2006) during a study of the Australian version of Deal or No Deal. In addition, a study of the United Kingdom version of the game showed similar results as well, although that version has only seven rounds versus the ten rounds played in the other two versions. A comparison of these studies (regardless of gender) is given in Figure 7. Note that although the numbers are different due to the sample sizes, the trends are essentially the same (see Figure 8). Note also that after round eight, the

Banker's offer drops considerably due to the fact that by this point, there are usually only small amounts left in play. By round ten, the player receives the amount in their initially selected case.

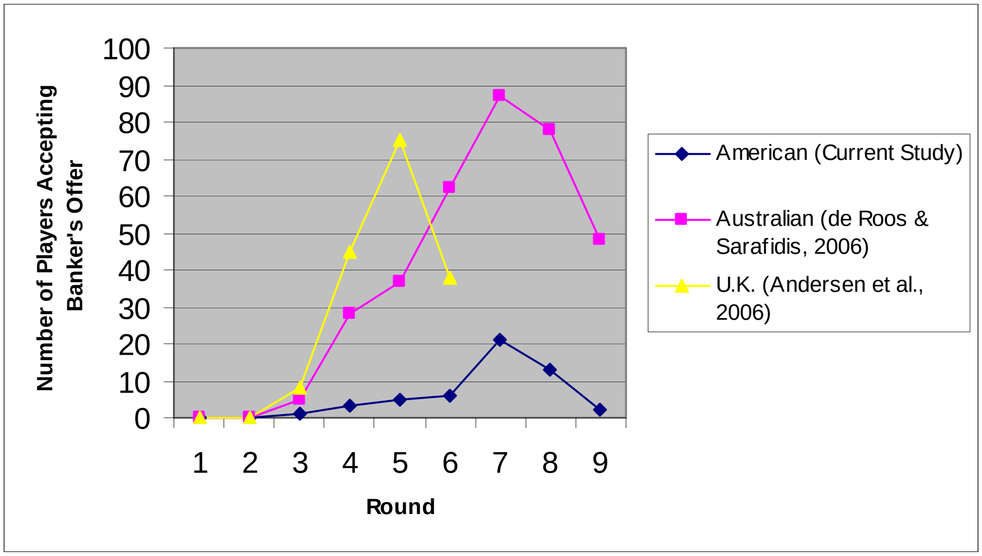


Figure 7. Number of Players "Taking the Deal" from Current American Study, Australian, and United Kingdom Studies (Based on Available Data)

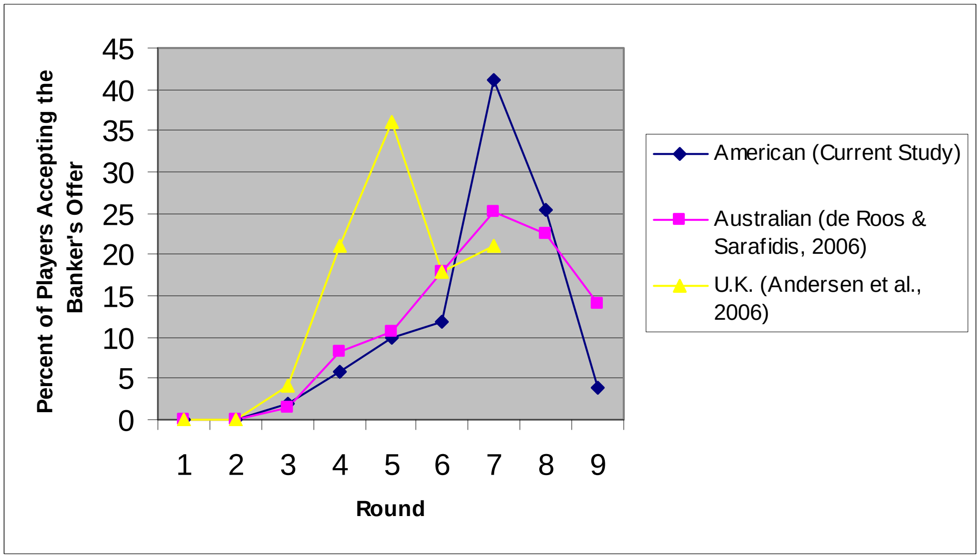


Figure 8. Percent of Players "Taking the Deal" from Current American Study, Australian, and United Kingdom Studies (Based on Available Data)

The Banker's Offer

The Banker's offer can have considerable influence on the decision that the player makes and both the offer and the decision are influenced by the player's perception of risk. de Roos and Sarafidis (2006) observed that the Banker's offer tended to increase in subsequent rounds of the game with respect to the expected value of the remaining unopened cases. By the round nine, the Banker's offer was essentially equal to the expected value. These findings were also confirmed by Andersen, Harrison, Lay, and Rutstrom (2006) as well as by this current study (see Figures 9 and 10 below).

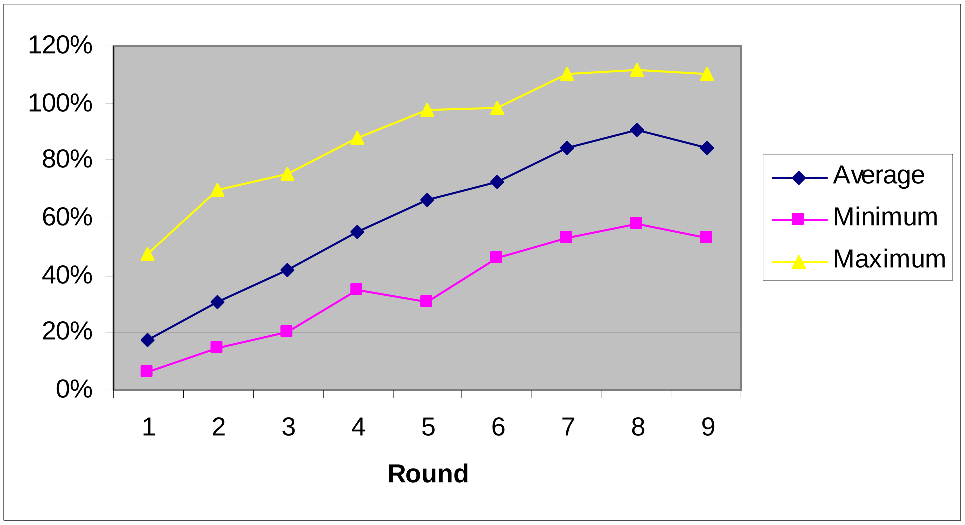


Figure 9. Percent of Average Banker's Offer to Expected Value of Remaining Cases by Round for the Current Study

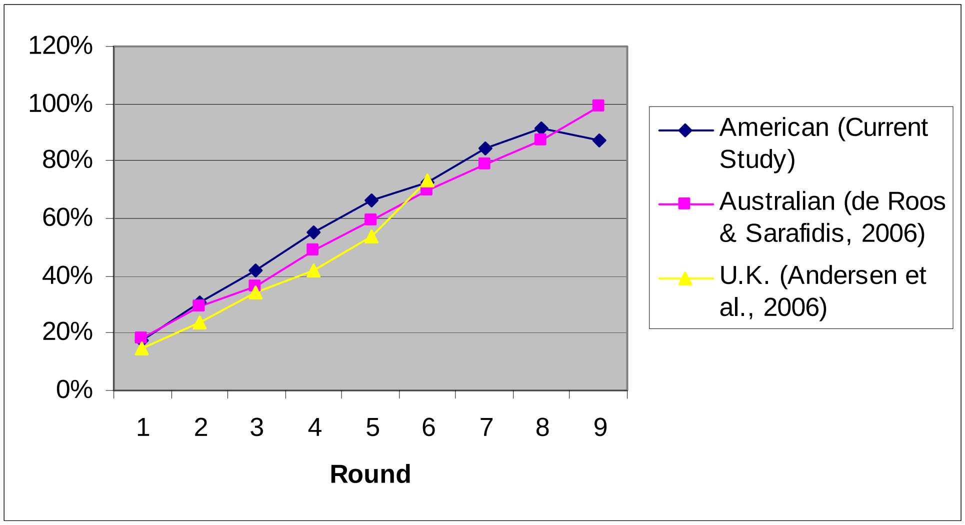


Figure 10. Percent of Average Banker's Offer to Expected Value of Remaining Cases by Round for Three Studies

For the current study, the expected value (EV) and standard deviation (SD) of the remaining unopened cases were calculated as:

$$EV = \sum_{i=1}^{n} x_i p_i$$

where

n = number of unopened cases　　Eq 11.

$p = 1/n$

x = \$ values remaining in play

$$SD = \sum_{i=1}^{n} (x_i - EV)^2 p_i$$

where

n = number of unopened cases　　Eq 12.

$p = 1/n$

x = \$ values remaining in play

EV = Expected Value

These calculations for the current study are given in Table 8 below. In addition, Table 9 gives the average Banker's offer per round over all players. Both the average Banker's offer and expected value of the amount left in play are represented graphically in Figure 11.

Table 8. Expected Value of Cases Remaining in Play by Round

Round	EV	SD	Min	Max
1	$131,333.28	$ 27,902.96	$63,379.55	$170,808.05
2	$139,117.08	$ 45,196.14	$17,730.40	$221,797.00
3	$134,422.89	$ 62,347.07	$19,622.82	$271,388.73
4	$132,273.45	$ 85,018.47	$15,865.75	$370,006.38
5	$123,942.34	$ 95,449.51	$ 180.17	$441,675.17
6	$120,368.20	$ 93,273.04	$ 66.20	$380,010.20
7	$125,143.73	$112,066.53	$ 21.25	$375,012.75
8	$117,176.36	$118,205.02	$ 20.00	$383,466.67
9	$ 17,593.73	$ 30,738.22	$ 3.00	$ 87,500.00

Table 9. Average Banker's Offer by Round				
Round	Avg.	SD	Min	Max
1	$ 23,880.18	$ 13,434.13	$ 4,000.00	$ 80,000.00
2	$ 43,718.75	$ 24,225.44	$ 7,000.00	$153,000.00
3	$ 57,921.88	$ 35,661.68	$10,000.00	$169,000.00
4	$ 74,270.63	$ 59,303.58	$12,000.00	$292,000.00
5	$ 80,986.08	$ 73,101.49	$ 150.00	$411,000.00
6	$ 83,835.27	$ 67,779.52	$ 40.00	$347,000.00
7	$103,432.65	$ 96,409.40	$ 20.00	$377,000.00
8	$102,539.54	$111,141.60	$ 22.00	$402,000.00
9	$ 17,587.27	$ 31,120.84	$ 3.00	$ 83,000.00

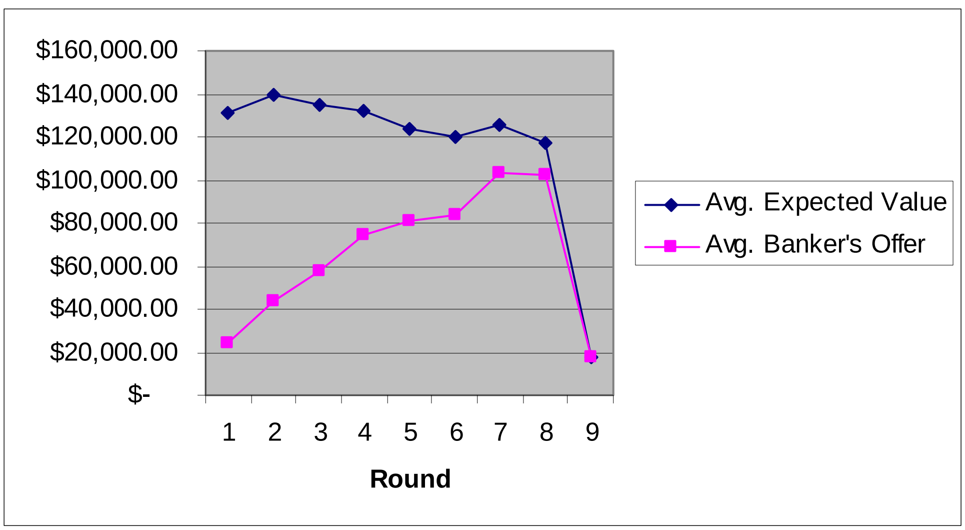


Figure 11. Comparison of Expected Value of Remaining Cases and Banker's Offer for All Data

Figure 11 confirms the finding by de Roos and Sarafidis (2006) that by the last two rounds, the Banker's offer is almost equal to the expected value. This is most likely due to the fact that at this point in the game, the probability that the initially selected case holds the highest value remaining in play is much higher (i.e., 1/3 by round eight and 1/2 by round nine), thus the Banker increases his offer (with respect to the expected value) to entice the player to end the game and leave with less money than they could potentially win. As mentioned before, the lower offer in round nine relates to the lower expected values for this round.

Risk Averse versus Risk Seeking Behavior

In studying the Australian version of Deal or No Deal, Mulino et al. (2006) discussed the dynamics of decision making in terms of myopic versus forward-looking players. Mulino et al. described myopic players as comparing the Banker's offer to the probability of winning the values that remain in that round. It is a somewhat short-sited view because these player do not consider that the offer will dynamically change as the game continues. Thus, it would seem that these players would be more risk seeking, willing to risk all for one more chance to play when in reality, if they had looked forward, then they would have realized that they should have taken the Banker's offer. Perhaps these players are more influenced by desire, regret, and influence from the audience and supporters and thus are unable to make a decision based on analytical reason (i.e., low-numeracy individuals as described by Peters et al., 2006). On the other hand forward-looking players do just that—they look ahead to analytically estimate what could be if they didn't take the Banker's offer (i.e., high-numeracy individuals; Peters et al., 2006). By analyzing the potential to win more money if they refused the offer and stayed in the game, it would seem that forward-looking players are perhaps risk averse. These players are able to visualize the potential outcomes and thus take advantage of the best offer from the Banker. To examine this further, players from the current study were divided into two groups: risk averse (i.e., those players who took the Banker's offer by at least round nine; *n*=51) and risk seeking (i.e., those players who refused the Banker's offer and stayed in the game until round ten; *n*=13).

It is obvious from Figure 12 that the myopic risk-seeking players fared poorly by staying in the game until round ten. Although much lower than the expected value of the cases remaining in play, the Banker's offer peaked at round four and never recovered. If these players were risk averse, they most likely would have taken the offer in round four. As was seen earlier, the Banker's offer and expected value converge by rounds eight and nine.

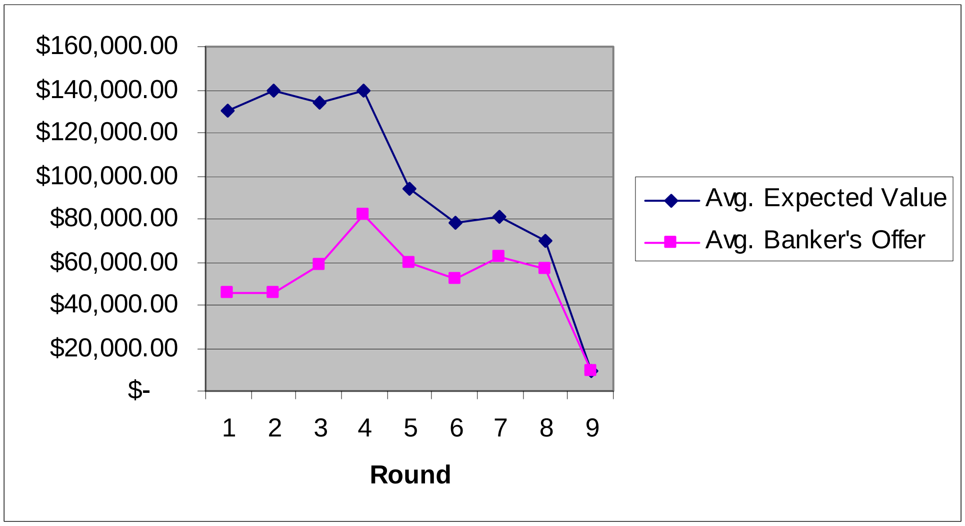


Figure 12. Comparison of Expected Value of Remaining Cases and Banker's Offer for Risk Seeking Players

Figure 13 compares the average expected values against the average Banker's offer for the risk averse (i.e., forward-looking) players. This trend is similar to that seen for the overall data (Figure 11). As was shown before, the Banker's offer tended to increase throughout the game until it converges with the expected value. In this study, this convergence occurred in rounds eight and nine. As mentioned earlier, most players accepted the Banker's offer and exited the game by rounds seven and eight. Figure 13 shows that round eight was the peak round for the risk averse players and by round nine, most of the high values were eliminated thus reducing the expected value and ultimately the winnings.

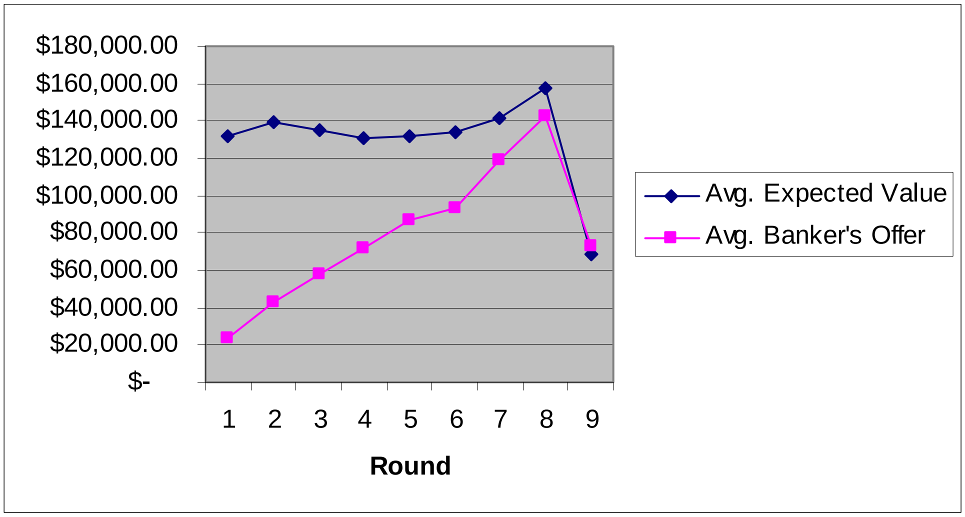


Figure 13. Comparison of Expected Value of Remaining Cases and Banker's Offer for Risk Averse Players

Figure 14 shows that the risk seeking players performed equally as well as the risk averse players until round four. After that, these myopic players seemed to make wrong choices, refusing the Banker's offers until it was pointless to stop. Realizing the hopelessness of the situation, many times the player would simply exclaim that they came with nothing, so they might as well go all the way and leave with nothing, which was usually the case. Because their choice of cases resulted in lower expected values, the Banker's offers were lower as well when compared to the forward-looking players (see Figure 15).

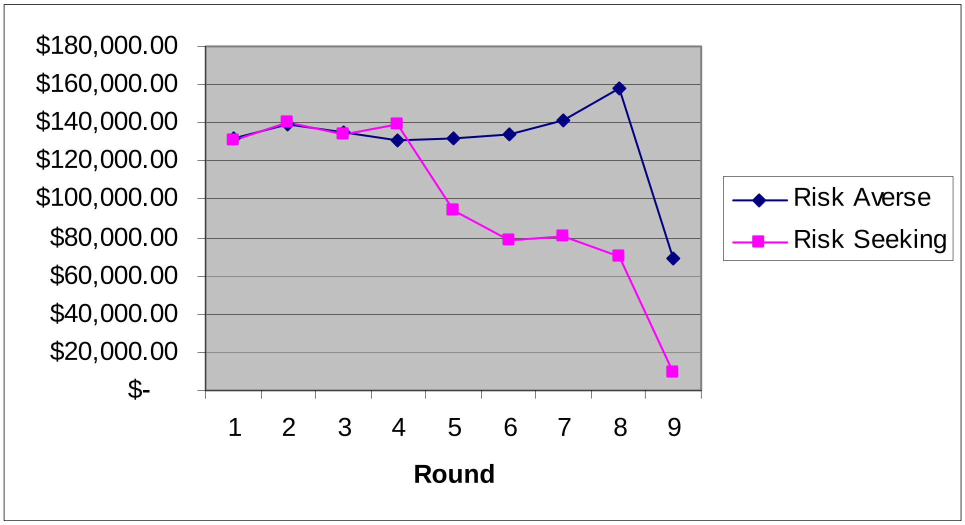


Figure 14. Comparison of Expected Value of Remaining Cases for Risk Averse and Risk Seeking Players

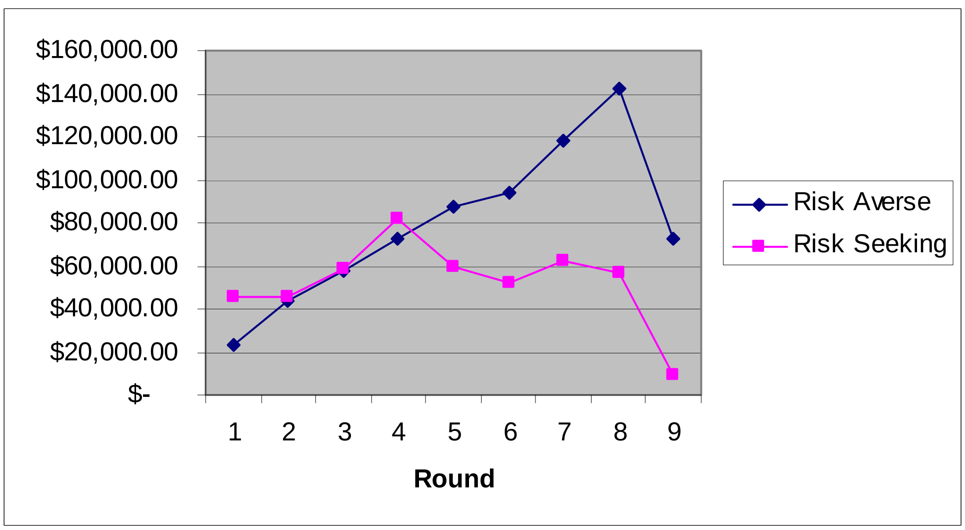


Figure 15. Comparison of Banker's Offer for Risk Averse and Risk Seeking Players

When comparing the winnings of the risk seeking players versus the risk averse players (see Figure 16), it is obvious that those who played it safe walked away with more money. The average winnings for the risk averse players (averaged over rounds one through nine) was

\$106,619.71 as compared to \$12,561.23 for the risk seeking players (Table 10). A *t* test for the hypothesis of equal means ($H_0 : \mu_{RiskSeeking} = \mu_{RiskAverse}$) was performed assuming unequal variances ($p(F \leq f) = .0001$). At the $\alpha = .01$ significance level, there was a highly significant difference between the amount of money won by risk level ($p = .0000$).

Table 10. Average Winnings by Risk Level

	Winnings	
	Risk Seeking	Risk Averse
Average	\$ 12,561.23	\$106,619.71
Std. Dev.	\$ 29,652.79	\$ 84,990.89
Minimum	\$100,000.00	\$402,000.00
Maximum	\$ 1.00	\$ 150.00

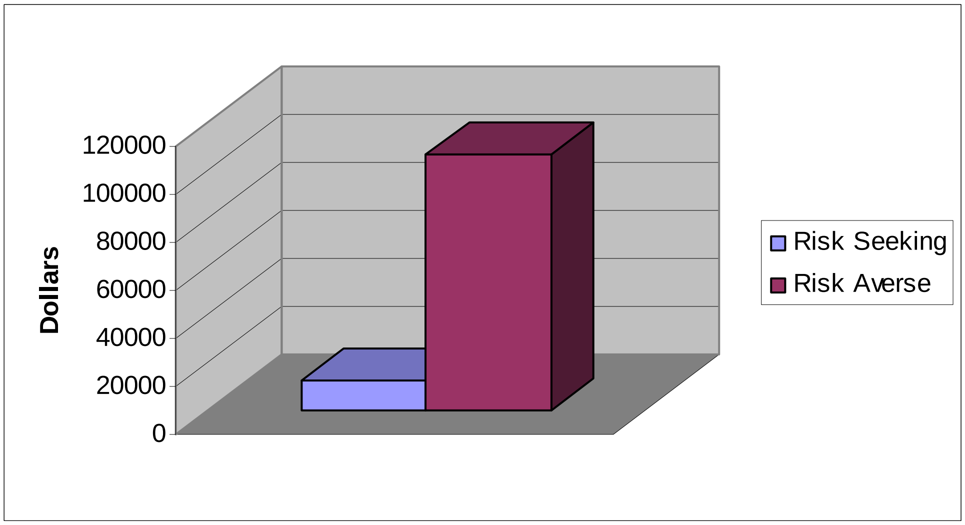


Figure 16. Average Winnings for Risk Averse and Risk Seeking Players

Conclusion

The phenomenal international success of Deal of No Deal has enticed economists, psychologists, and mathematicians alike to study various aspects of this game show. Still in its infancy, much of this research is ongoing. This study has shown that even though Deal or No Deal games played in different countries may follow different rules, the versions are still similar with respect to risk perception and the Banker's offer. Regardless of where the game is played, the goal of the Banker is to get the player to leave the game with as little money as possible. The basis of the Banker's offer is the expected value, that is, the average amount of money left in play in a round. There also appears to be a random risk factor built into this offer that is based on the player's attitude towards risk.

In this study, risk was assessed based on gender. Although gender differences with respect to risk aversion are not new, this study showed that these differences continue to exist within the precepts of this game show. The results showed that there was a significant difference between male and female players in terms of winnings. One possible reason why female players may win more money than males is because of this risk factor. If the Banker senses that the player is more risk averse, he may increase his offer to get the player to end the game. However, since the Banker's offer is based on the expected value, the higher offers may also indicate that the female players simply make better random choices resulting in higher values left in play and as a result, higher offers from the Banker. The Banker also purposefully tries to intimidate the player through various psychological means. Thus, if female players really are more risk averse, they may choose to end the game sooner than the male players in order to avoid the stress, embarrassment, and/or intimidation presented by the Banker.

The vary nature of this game show promotes risk seeking behavior that is contrary to prospect theory. However, when risk was assessed based on myopic versus forward-looking behavior, the majority of players were classified as risk averse. This study showed that players who were risk seeking performed more poorly and won significantly less money than the risk averse players. Deal or No Deal is a game of numbers and probabilities. Players who can intuitively assess or analytically analyze risk (as McMackin and Slovic, [2000] suggested) based on the expected value of the dollar amounts left in play win more money than those who don't simply because they can sense the right time to accept the Banker's offer and exit the game. This type of behavior is risk averse but works in favor of the player in this game.

Deal or No Deal provides a natural opportunity to observe risky behavior in a controlled environment. As such, more demographic data (such as age, race, and occupation) and additional analyses could lead to greater discoveries concerning the assessment of risk. For example, not only could risk be assessed with respect to age, race, and gender, but the interaction effects (if any) of those variables could be assessed as well using ANOVA. In addition, if a pre-test could be given to each player, their aversion to risk and current asset position could be evaluated beforehand and then compared to their game results. In either case, much more information would need to be collected. However, the potential to further understand the human decision making process will most likely cause this game to be studied for a long time to come.

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