# Does Economics Need A Psychologist ? Behavioral Models Challenging Expected Utility In A Context Of Gambles

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**Abstract**

This thesis investigates the very concept of behavioral economics in relation to expected utility. A comparison between the standard way to measure utility and alternative manners is executed. More precisely, prospect theory, disappointment theory and regret theory give new and additional psychological perspectives into economics. These aspects embrace behavioral components that influence the final utility. I find this approach useful to reflect human economic behavior where classical economic models fail. To explain, reference dependence, disappointment protection and gambling addiction are analytically addressed. Moreover, I develop the gambling trap to understand persistent and aggressive gambling despite repetitive losses.
Keywords: expected utility, prospect, regret, disappointment, gambling.

## 1 Introduction

During the last decades a challenging theoretical movement in economics, offering alternatives to the expected utility theory (EU), has emerged. Its underlying stream of critique attacks the theoretical frames of standard economics.

Most economic models integrate uncertainty and a time element. The classical model offers a menu of assumptions e.g., the utility function is purely instrumental, selfish and depends on absolute levels and not on changes and when people face risky choices they maximize expected utility. Furthermore,

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implicit assumptions like exogenous, well-defined and stable preferences exist. However, the criticism against these assumptions has increased in strength.

In a behavioral perspective, preferences are said to depend on adaptations and reference points rather than final assets. Moreover, people are not assumed to be narrowly self-interested and thinking of people as maximizing utility functions is said to be the wrong way to conceptualize economic behavior. Partly, because people do not completely know their preferences and therefore are open to influences by the environment (Koszegi, 2004). For considerable time it has been assumed that most economic agents should follow the cornerstones of expected utility and furthermore that they actually do. Hence, the EU theory not only aspires on normative aspirations. It also claims to be a descriptive model that people would follow in most cases.

Allais (1953) showed a paradoxical result to expected utility. However, he worked with various combinations of the EU, rather than changing its underlying assumptions. Steps taken in this direction to modify the axioms were taken in the late 1970's and early 1980's. Hereby, new axioms were developed and formalized where behavioral phenomena were an integrative part. These developments came to form behavioral economics, which mainly is the application of psychological theories and concepts to human economic behavior. Its counterpart in business administration is behavioral finance.[1]

However, critics of behavioral economics often emphasize their full confidence in the rational economic agent. Furthermore, they claim that psychologist often offer concepts and ideas, but seldom coherent theories (Kahneman, 2003b). Traditional economists also doubt that human economic behavior extracted from experiments is applicable to market situations, and that experimental behavior hardly works as a good proxy for market behavior.

## 1.1 The role of Psychology in Economics

Psychology is focused on studies of human behavior and mind. Economists have often been accused of to reject or ignore the psychological dimension influencing economic choices. A certain field, economic psychology, attempts to capture behavior so far ignored or left unexplained by economic theory. Psychology is often viewed as providing additional findings and evidence to give a better sense and understanding for economic issues.

The science of economics has been constructed upon several strong assumptions of human rationality. However, it lacks substantial experience regarding human thought and mental processes generating these results, such as outcome and choice (Antonides, 1991). Economists have, ex-ante, put restrictions on these processes in order to make them easier to handle. Economic psychologists have through gathering information on mental processes, ex-post, been able to analyze economic outcomes. This might be the principal argument to how and

[1] The scientific clash between behavioral finance and traditional finance is mainly a dispute of what traditionalists call market anomalies. Behavioral proponents want to make their own theories out of these anomalies with help of human psychology.

why different branches of psychology could contribute to a broader understanding of economic behavior. In this context cognitive psychology plays a crucial part where the study of human reasoning is in focus, often with an experimental touch.[2]

Rabin (1998) defends the application of psychology in economics. He stresses that behavioral results often are reproduced in different situations and in various countries which could give good behavioral insights into standard economics. Other advocates of the behavioral school point out that neoclassical theory mispredicts outcomes in reality and that behavioral economics has models that predict outcomes satisfactory where the neoclassical models fail.

## 1.2 Purpose

The overall aim of this thesis is to introduce, explain and further motivate how psychological concepts can influence and explain human economic decisions. This behavioral approach is based upon the will to reflect and more correctly understand economic behavior, which classical economics so far more or less has ignored. More precisely, the principal purpose is to explore how behavioral theories can contribute to a broader understanding of human decisions in a context of gambles and choices under uncertainty. Moreover, there is a focus on psychological components violating assumptions belonging to the expected utility theory.

The methodological approach consists of a thorough overview and comparison of existing theories. I concentrate the behavioral theories to three of a kind: prospect, regret and disappointment. In other words, they are to be scrutinized to see in what way they can improve and better reflect the economic agent's decision-making compared to expected utility. Experiments will be commented on and referred to, in order to illustrate how behavioral patterns can influence economic choices.

Moreover, this thesis borrows psychological concepts, explanations and understandings to make economic choices and outcomes more understandable and comfortable in a context of human reasoning and inference.

## 1.3 Structure

This thesis is organized in a certain way. The introduction is followed by a thorough overview of the expected utility theory. In chapter 3, prospect theory will be introduced and scrutinized. In the two next following chapters, regret and disappointment theory will be in focus. Chapter 6 contains an analytical discussion. The final chapter has concluding comments.

[2]See Antonides (1991) for an overview of several psychological branches and concepts.

# 2 Expected Utility

The founding fathers of expected utility theory Johan von Neumann and Oskar Morgenstern (1944) investigate the central problem of human rational economic behavior.

Probably, the most difficult task is to describe and formalize the economic motives of a single individual. This has traditionally been done and downsized to one sentence: human beings are assumed to maximize utility. The way to practically handle the meaning of utility is yet another problem and how to measure and numerically determine the utility value. However, the EU solves for this through a simplification, where money could be used as a proxy for utility. This seems to be reasonable since money could be used to achieve utility as exchanges for goods or services in order to obtain utility e.g., via a market. In a very simple form utility is a non-satiable assumption i.e., more utility or more money is always desired over less of the same kind. In conclusion, an individual striving for more utility over less is said to be a *homo economicus* and showing a *rational* economic behavior.

Expected utility treats preferences and utilities by focusing on preference orderings, mathematical functions and numerical values. This implies that other possible subjects attached to the utility terminology are left out or ignored due to the focus on the numerical utility maximization.

The EU is basically a theory representing decision-making under risk or uncertainty. That is, a theory for choosing amongst acts when the economic agent does not know for sure which consequences will emanate from the act chosen.

## 2.1 The Model

Expected utility has several axiomatic assumptions that postulate the behavior of the economic agent. Jensen (1967) and Fishburn (1970) reduced and refined the number of axioms to three. Schoemaker (1982) lists five different axioms which the classical model is based upon, which I intend to follow. These imply numerical utilities for outcomes of lotteries or consumption, revealing the order of preference over consumption or lotteries. To summarize, greater expected utility is related to higher preference.

The five basic axioms in the EU-Model are:

**Axiom 1** *Completeness and Transitivity. Individual preferences are said to be complete. That is, the economic agent has a clear preference for any two given objects or choice he is exposed to. That is, the model expects him to be able to say which one of the two he prefers. Therefore, preferences for goods* ($G_i$) *are said to be complete and transitive. Completeness says that for any choice between goods* $G_1$ *and* $G_2$ *holds*: $G_1 \succ G_2$*, or vice versa* $G_1 \prec G_2$*, or they could be equivalent attractive*: $G_1 \sim G_2$*. Transitivity means that given* $G_1 \succcurlyeq G_2$*, i.e.,* $G_1$ *is weakly preferred to (at least as preferred as)* $G_2$ *and* $G_2 \succcurlyeq G_3 \Longrightarrow G_1 \succcurlyeq G_3$*. That is,* *without any direct "competition" in choice between $G_1$ and $G_3$, the conclusion via $G_2$ render a logical result: $G_1 \succcurlyeq G_3$.*

***Axiom 2*** *Continuity. Ensures it always is possible to find a mix of probability that combines the extreme outcomes to generate a third one that is indifferent between any outcome in-between the extremities. To illustrate, assume a lottery with three possible outcomes, where: $X_1 \succ X_2 \succ X_3$, there exist some probability $p \in [0, 1]$ such that the lottery $p * X_1$ and $(1-p)X_3$ is as desirable as getting $X_2$ for sure.*

**Axiom 3** *Independence. Given one alternative is more desirable than another, an equivalent combination of probability with a third alternative will not change the preference order. The preferences are thus said to be independent of any common components. As a result of this axiom there is invariance of preferences between risky and certain situations. To illustrate, if alternatives $X_1$ and $X_2$ are identical attractive, then the lottery $p * X_1, (1-p) * X_3$ and lottery $p * X_2, (1-p) * X_3$ also are identical attractive for any $p$ and $X_3$.*

***Axiom 4*** *Desire for high probability of benign outcomes Assume two lotteries where one is preferred to the other and the probability $(p)$ increases for the preferred outcome. Then the "new" alternative will be preferred to the "old" most desirable alternative. Consider two lotteries $(L_{i=1,2})$ with outcome $(X_{i=1,2})$ and probabilities $p$ and $q$: $L_1 * p \rightarrow X_1, L_1 * (1-p) \rightarrow X_2$ and $L_2 * q \rightarrow X_1, L_2 * (1-q) \rightarrow X_2$ i.e., only differing in probability. So, if $X_1 \succ X_2$ then the former lottery will be the most preferred if and only if (iff) p›q.*

***Axiom 5*** *Rules for combining probabilities. A compound lottery, whose outcomes per se are lotteries, is as attractive as its outcomes when multiplying their probabilities according to standard theory of probability. That is, the simple lottery∼complex lottery.*

These axioms altogether form the foundation the EU relies on. Moreover, these assumptions are enough to promise the existence of a utility index so that the ordering of lotteries, alternatives or outcomes fully converges with one's real preferences (Schoemaker, 1982).[3]

Furthermore, these axioms give the utility function, $U(x)$, following properties: ($i$) $U(x)$ preserves the order of preferences amongst risky alternatives. That is, $a$ is preferred to $b$ iff the utility of $a$ is greater than that of $b$. ($ii$) The function is linear in probabilities i.e., the compound lottery is the sum of its single lotteries.

A fundamental assumption of the EU theory is risk aversion. An individual who has risk averse attitude is mutually possessing concave preferences i.e., the certainty equivalence is less than expected monetary value. The Arrow-Pratt ratio measures local risk-aversion for $U(x)$. That is, the negative quota of the second to the first derivative: $-U"(x)/U'(x)$. This ratio is invariant given

[3] The classical theory usually represents preferences whilst the neoclassical determines preferences.

linear transformation and further it assumes an unchanged value for exponential as well as linear utility functions. This implies that risk preferences deduced from exponential or linear utility functions are insensitive to changes in the individual's wealth status (ibid). The principal concern is what happens if one or several of these axioms are violated or relaxed.

## 2.2 The Measurement of Utility

For some time social scientists have been occupied by debating how accurate it is to use scales to order e.g., utility, intelligence, creativity or happiness.[4] However, some variables in natural sciences as length and weight have been naturally established and accepted. Traditional economics argues that it is feasible to measure utility in a meaningful way (Coombs *et al.*, 1970).

Utility is often divided into two separate types: cardinal utility and ordinal utility. To simplify, cardinal utility makes it possible to rank and in a relevant manner compare different utility values. The ordinal utility is preoccupied by ordering utilities and cannot in a meaningful way make comparisons between different values as can cardinality. Common examples of cardinality are weight and temperature, which both use interval and ratio scales.

In the neoclassical approach cardinality is referred to as the strength of preferences i.e., intensity and direction. Intensity would be how deeply you really want your preference to be realized, whilst direction would be how you would rank your alternatives. For example, assume you prefer a Saab to a Volvo and furthermore you prefer a Volvo to all other cars. Then this would be the direction of your ranked preferences (ordinal utility). However, the intensity is not elicited just by pure ranking. Intensity reveals how much more you prefer a Saab to a Volvo or a Volvo over a Toyota for instance. This is done by using interval and ratio scales. In sum, the ordinal utility is one-dimensional whilst cardinality has two dimensions.

The expected utility is cardinal insofar that it uses interval to represent and measure utility. However, in rankings of lotteries the EU model is ordinal (Schoemaker, 1982). Hence, the cardinal property in an expected utility context must be used cautiously.

Preferences over lotteries are decided by foremost two parameters: $(i)$ strength of preference under certainty and $(ii)$ risk attitude. The EU model is a cocktail of these two. The cardinal utility is separated in two directions. The first one is made under certainty, denoted $v(x)$ and the second is constructed under risk, denoted $u(x)$. Consequentially, there exist various forms of cardinality. The difference is mainly to be found in which context the utility function is constructed, under certainty or risk. The $v(x)$ function is constructed as an interval-scaled measure given certainty, whilst the $u(x)$ is deduced amongst risky lotteries.

[4] See Coombs *et al.* (1970) for a deeper discussion.

## 2.3 The Measurement of Probability

Outcomes as consequences of behavior and states of the world are usually regarded as uncertain. These outcomes are evaluated comparing their probability of realization. Hence, decision-making is presumed to have a component of evaluation. This process may take place in different manners. Economic theory under the EU model assumes that people in general try to maximize:

$$\sum_{i=1}^{n} F(p_i)\, U(\underline{\mathrm{x}}_i)$$

where $n$ equals possible outcomes, $p$ is set as the objective probability and $\underline{\mathrm{x}}_i$ is a vector of outcome elements (Antonides, 1991). These outcomes are evaluated through a value function, $U(\cdot)$, and the objective $p$'$s$ are treated in weight by a function $F(\cdot)$.

Risk is treated in the traditional manner i.e., where probabilities of outcome are known or at least possible to reveal, whilst uncertainty contains unknown probabilities or are impossible to discover. In the classical utility model probabilities are treated objectively and as given (Schoemaker, 1982). A subjective probability is an individual's personal assessment of how likely an outcome is to come true.

The simplest version of the EU model is the expected monetary value (EV).[5] Here, the objective values of the outcomes are to be weighted by their corresponding objective probabilities. The EV model assumes risk neutrality i.e., the agent maximizes only expected value independent of risk. Hence, given the assumption that individuals are risk averse, the model does not correctly reflect preferences.

A more complex form has an intrinsic assumption that a lottery is evaluated in a way that the utilities are weighted via their objective probabilities, respectively. Under this circumstance, the generalized function for two outcomes $x$ and $y$ and probability $p$ attached to the realization of $x$ can be written: $pU(x) + (1-p)U(y)$. Following the assumption that risk aversion rules: $U[px + (1-p)y] > pU(x) + (1-p)U(y)$, for $x$ , $y$ and $p$ as above. This inequality explains risk aversion. To put it different, the utility function shows a concave property, which logically is related to decreasing marginal utility.

Lastly but most important, the EU model treats outcomes as final states. That is, the assets possessed before the gamble took place and the gains/losses yielded from the gamble are all absorbed.

## 2.4 Paradoxes

Several famous and well-known experiments have shown obvious violations to the expected utility.[6] I will introduce two of the most frequently cited violations:

[5] Schoemaker (1982) lists nine types of the Expected Utility Model.

[6] See Enemark (1994) following Machina (1982,1987) who lists e.g., preference reversal and framing effects. Antonides (1991) has the well-known St. Petersburg paradox.

($i$) The Allais Paradox and ($ii$) The Ellsberg Paradox.

($i$) The Allais paradox systematically violates the independence axiom. In an experiment individuals were asked to choose between two pairs of prospects: $(outcome(Million franc), probability)$

$$\begin{aligned} A &= (100M, 1.00) \text{ i.e., for sure} \\ B &= (500M, 0.10; 100M, 0.89; 0, 0.01) \\ &\quad \text{and} \\ C &= (100M, 0.11; 0, 0.89) \\ D &= (500M, 0.10; 0, 0.90) \end{aligned}$$

According to the independence axiom any feature such as the 89% chance to win $100M$ choosing between $A$ and $B$, and the 89% risk of gaining nothing choosing between $C$ and $D$, should not disturb the ranking of the choices made. Moreover, if these features were erased the two pairs of choices are identical. That is, a choice between winning $100M$ with 11% chance, for $A$ and $C$ and gaining $500M$ with 10% chance and to get 0 with 1% risk, for $B$ and $D$.

The prediction of the EU model says that if you have chosen $A$ over $B$, then you must choose $C$ over $D$. However, the result of the experiment contradicts this prediction since most people preferred $A$ over $B$ and $D$ over $C$ (Allais, 1990).

The conclusion of the Allais paradox is that people in general have a stronger positive bias towards small chances of good outcomes and stronger aversion for small risks of bad outcomes than the EU would predict. This means that the probability has an overweighting effect for small probabilities. This renders risk seeking in case of good outcomes and risk aversion towards bad outcomes. In other words, probability is not treated linearly.

($ii$) The Ellsberg paradox violates the assumption that probabilities can be estimated subjectively. The fundamental example, the "red and black color" problem, has two urns containing red and black balls. The first urn has 50 red and 50 black balls out of 100 balls. The second urn has 100 red or black balls and each ball being red or black is equally likely i.e., random. However, the actual proportion is unknown.

Assume one ball is drawn randomly from an urn and the pay-off is $100 or $0 depending on outcome. The experiment shows that most people are indifferent between choosing red or black for either urn (Ellsberg, 1961). However, they prefer the $50 - 50$ urn over the unknown urn.

That is to say that people weigh the argument for known probability higher than that of unknown, despite the random average proportion of the second urn is $50 - 50$. In sum, this result is not consistent with EU because the subjective probabilities are greater in the first urn than the second. This implies that the subjective probabilities cannot sum to one for both urns, which expected utility predicts they do. Hence, there is a psychological weight which makes the first urn more attractive than the second.

This phenomenon is usually explained by ambiguity. That is, people prefer clear bet more than they prefer vague bet with somewhat unclear information. Although, the chance red or black ball is being drawn from either urn is 1/2.

## 3 Kahneman-Tversky Criticism

In 1979 Daniel Kahneman and Amos Tversky published an influential behavioral paper: *Prospect Theory- An Analysis of Decision under Risk.* This theory came to rival expected utility in how to reflect economic decision-making.

Kahneman and Tversky (KT) tackle the problem by an approach of choice between gambles or *prospects.* In this context a prospect $(x_{1,}p_1; x_2, p_2; ...; x_n, p_n)$ is a contract or gamble that yields the outcome $x_i$ with the probability $p_i$, where the probabilities sum to 1.

Usually, there are three components when applying the expected utility theory between prospects:
($i$) Expectation: $U(x_1, p_1; x_2, p_2; ...; x_n, p_n) = p_1u(x_1) + p_2u(x_2) + ... + p_nu(x_n)$. That is, the sum of a utility belonging to a prospect,$U$, is the expected utility of its outcomes.
($ii$) Integration of Asset: $(x_1, p; x_2, p_2; ...; x_n, p_n)$ at asset position $w$ iff $U(w + x_1, p_1; w + x_2, p_2; ...; w + x_n, p_n) > u(w)$.
To put it different, a prospect is acceptable if the utility emanating from integrating the prospect with one's assets exceeds the utility of these assets valued alone. Hence, the final states include the individual's wealth or asset position rather than focusing on changes i.e., gains or losses.
($iii$) Risk Aversion: $u$ is concave, which implies that the second derivative is negative ($u$" $<$0).

KT list several counter-examples violating these three components:
· The *certainty effect* means that individuals tend to overweight benign outcomes regarded as certain in comparison to outcomes perceived as merely likely. In the EU model, the utilities of outcomes are weighted by their probabilities.
An experimental example following Allais (1953) may explain: ($\$outcome, probability$)
Consider the first problem:

$$A = (\$4000, 0.80)$$
$$B = (\$3000, 1.00)$$
95 respondents, 20% chose $A$, logically 80% chose $B$.

Consider the second problem:

$$C = (\$4000, 0.20)$$
$$D = (\$3000, 0.25)$$
where 65% went for $C$ and the rest, 35% preferred $D$.

These two problems violate the EU theory insofar that reducing the probability of winning from 1.00 to 0.25 has a greater impact than reducing from 0.80 to

0.20. However, the substitution axiom says if $B \succ A$, then any mixture of probabilities attached to $B$ must be superior to any mixture belonging to $A$. That is, $D \succ C$. Apparently, people change preferences; this is inconsistent to the substitution axiom.[7]

· The *reflection effect* is the mirror image to the certainty effect because it embraces negative outcomes (losses) instead of positive outcomes (gains). Experimental data show risk aversion in the positive domain and risk seeking in the negative domain. That is, concavity for positive values and convexity for negative values (Kahneman and Tversky, 1979). This is the reversed reflection.

· The *isolation effect* is an effect describing how people focus on the properties that distinguish alternatives rather than common features. This could create inconsistent preferences since a pair of gambles can be interpreted into common and specific features in more than one way.

To illustrate, consider following two problems:

($i$) In addition to your current wealth you have been given \$1000. Now you have to choose between:

$$\begin{aligned} A &= (\$1000, 0.50) \\ B &= (\$500, 1.00) \\ & N = 70,\ 84\% \text{ chose } B \text{ over } A. \end{aligned}$$

($ii$) In addition to your current wealth you have been given \$2000. Now you have to choose between:

$$\begin{aligned} C &= (\$-1000, 0.50) \\ D &= (\$-500, 1.00) \\ & N = 68,\ 69\% \text{ chose } C \text{ over } D. \end{aligned}$$

This is in line with loss aversion and the reflection effect above. However, in terms of final assets:

$$\begin{aligned} A &= (\$2000, 0.50; \$1000, 0.50) = C \\ B &= (\$1500, 1.00) = D \end{aligned}$$

The second problem is constructed from the first problem by adding \$1000 to the initial bonus and subtracting \$1000 from all outcomes. Obviously, the individuals isolated the bonus with the gambles. That is, the bonus was not regarded when comparing the prospects because it was common to both alternatives within each problem.

[7] These findings suggest empirical generalizations in which the EU axiom of substitution is violated. This, violated, axiom says that if B is preferred to A then any mixture of probabilities (p) rendering (B,p) by necessity must be preferred to the mixture of (A,p). This modification is incorporated and presented by the prospect theory.

In comparison, this result violates the expected utility which predicts that the same utility is associated to a wealth of say $10.000, regardless if it was achieved from $9500 or $10.500. In other words, there is no psychological momentum embraced by the EU model.[8] Thus, there is no mental well-being following a gain and mental ill-being following a loss, when the final utility of $10.000 is evaluated.

## 3.1 Prospect Theory

Prospect theory defines two different phases, the editing and evaluation phase. The first phase contains a rudimentary analysis of the offered prospects which often generates a representation of these prospects. In the subsequent phase the edited prospects are evaluated and logically the prospect with the highest value is most preferred, and hence chosen.

The essence of the editing phase is to formulate and organize the options, in order to simplify the evaluation and choice. This stage consists of several operational components.[9]

The total value of an edited prospect is denoted $V$ and consists of two components: $\pi$ and $v$. Where $\pi$ is associated with a probability rendering a decision weight $\pi(p)$, which reveals the importance of $p$ on the total value of the prospect. However, the assumption that $p$ is a probability measurement is relaxed and $\pi(p) + (1 - p)$ is usually less than 1 (unity). The second parameter $v$ attaches to each outcome, of $x$, a number $v(x)$. This number reflects the outcome's subjective value. Furthermore, $v$ captures the reference-point which is set to zero and any deviation from that point represents gains (+) or losses (-).

A simple prospect can be formulated: $(x, p; y, q)$, which means that the prospect has maximally two positive or negative outcomes. In this context you receive $x$ with probability $p$ and $y$ with probability $q$. Moreover, you can obtain nothing with the residual probability i.e., $(1-p-q)$, given $p+q \leq 1$. A prospect is said to be strictly positive if $x, y > 0$ and $p + q = 1$ and strictly negative if all possible outcomes are negative. However, if neither of these two requirements is met the prospect is said to be regular (ibid.).

If $(x, p; y, q)$ is regular i.e., either $p + q < 1$ or $x \geq 0 \geq y$ or $x \leq 0 \leq y$. Following equation, where $\pi$ and $v$ are combined to evaluate the total value of regular prospects, holds:

[8] I define a psychological momentum as a psychological sentiment which, due to one or several consecutive good or bad events, constitutes a mood that influences the evaluation of the final utility.

One good event or a series of good events constitutes a positive momentum. Conversely, there is a negative momentum.

In other words, $10.000 is preferred going from $9500 than from $10.500. Because of $9500 has a positive momentum and $10.500 a negative momentum influencing the final utility of $10.000.

[9] These are: coding, combination, cancellation, segregation, simplification and detection of dominance. See Kahneman and Tversky (1979) for definitions.

$$V(x,p;y,q) = \pi(p)v(x) + \pi(q)v(y) \quad (1)$$

Here $v(0) = 0, \pi(0) = 0$ and $\pi(1) = 1$. $V$ is defined over prospects and $v$ is defined over outcomes, which is in line with standard utility theory. If the prospects are sure the two parameters equalize i.e., $V(x, 1.0) = V(x) = v(x)$. Equation (1) modifies the EU by relaxing the principle of expectation.[10]

However, the strict positive or strict negative prospects apply to a different rule. In the editing stage a prospect is divided into two components, a risk-free component and a risky component. The former reflects the actual certain gain/loss to be won or paid. The latter reflects what actually is at stake in terms of additional gain/loss. These prospects, strictly separated from 0 could be represented by their evaluation of these prospects according to equation:

$$V(x,p;y,q) = v(y) + \pi(p)[v(x) - v(y)] \quad (2)$$

The first component at RHS captures the risk-free part. The second, risk-bearing component captures the value-difference between possible outcomes and has an attached weight.[11] In sum, the value of a strict non-zero prospect is the value of the risk-free part plus the risky component multiplied with the belonging weight.[12]

To conclude, prospect theory principally deviates from expected utility in the way that values are associated with changes in wealth or welfare rather than to final states. Furthermore, the decision weights are not equal to the structure of stated probabilities. These deviations violate several fundamental principles of the expected utility. In other words, they form the cornerstones of prospect theory.

#### 3.1.1 The Value

The value of expected utility is concerned with values of final states, whilst prospect theory is focused on relative changes in relation to a certain point i.e., a *reference point*. To put it different, prospect theory evaluates changes rather than absolute levels of utilities. The main argument for this approach is based on psychological properties as personal judgment and perception (ibid.).

For example, historical and present experience of say temperature as in cold/warm climate sets an adaptation level of what the individual could refer to as her reference point when she categorizes warm and cold weather. That is, the reference level functions as a starting point from where deviations are perceived and evaluated. Furthermore, this level decides how the individual

[10] Kahneman and Tversky (1979) do an axiomatic analysis in their appendix.

[11] As a fan of financial economics I cannot avoid to draw a parallel to the heart of asset-pricing finance i.e., Capital Asset Pricing Model (CAPM). Here the overall return depends on the risk-free asset and the risky asset. The CAPM-formula states the total return to be: $r = R_f + \beta(R_m - R_f)$. Analogically, the first component at RHS is without risk and the second component contains risk.

[12] Noteworthy, if $\pi(p) + \pi(1-p) = 1$, then equation (2) could be reduced to equation (1) since the RHS of equation (2) is equal to $\pi(p)v(x) + [1 - \pi(p)]v(y)$.

reacts to changes in temperature which analogically could be substituted by changes in wealth or welfare.

The reference point as an adaptation level is highly subjective since it is a function of personal experiences. In other words, what could be perceived as low utility to one person might be of high utility to another. However, the focus on relative changes in terms of reference points does not *per se* imply that changes in wealth/welfare do not correspond to initial asset positions. The very ambition of prospect theory is to integrate and combine the reference point with the size of the change, away from that initial level. Moreover, a crucial assumption is that of concavity. This implies that people perceive the difference easier in e.g., temperature changes from $5^o$ to 10 $^oC$ than from $25^o$ to $30^oC$. This rule is also assumed to be applicable to monetary changes. That is, the difference in value between a gain of \$50 and \$100 is greater than that of \$1050 and \$1100. Likewise, the difference in value concerning a loss is greater between \$50 and \$100 than that of \$1050 and \$1100. In sum, the value function shows concavity for changes above the reference point i.e., $v"(x)$‹0, for $x$›0 and convexity below that point i.e., $v"(x)$›0,for $x$‹0. This constitutes the hypothetical value function:

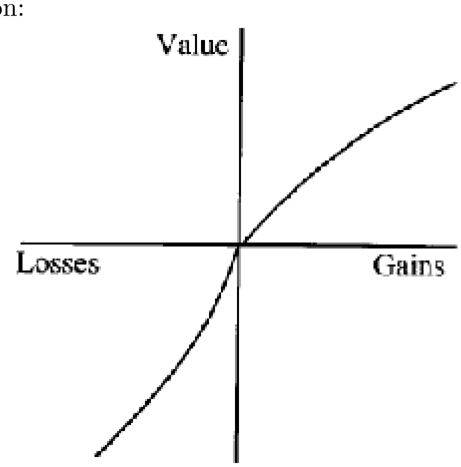


Figure 3.1- Prospect Theory's Value function.

In figure 3.1 the marginal value is absolutely decreasing with size in both positive and negative direction, creating a somewhat S-shaped function. That is, the function is kinked at the reference point and constitutes concavity for gains convexity for losses.

The value is a variable of two arguments: ($i$) the asset position (the reference point) and ($ii$) the magnitude of the change, away from the reference point. This implies decreased marginal utility for money above the reference point and decreased loss-aversion below the reference point.

The curvature of the value function is derived via following experiments (ibid.):

Choose between: ($\$outcome, probability$)

($\$6000, 0.25$) or ($\$4000, 0.25; \$2000, 0.25$).
Out of 68 respondents, 82% preferred the second gamble

Choose between:

($\$-6000, 0.25$) or ($\$-4000, 0.25; \$-2000, 0.25$).
70% chose the first gamble.

These results support the general shape of the value function: risk aversion in the first quadrant, and risk seeking in the third quadrant. However, there are examples of concavity in the loss-region and convexity in the gain-region. For instance, a family saving money to buy a $100.000-house may experience a marginal gain of money from $95.000 to $100.000 more pleasurable than a gain from $80.000 to $85.000. That is, increased marginal utility for money. In the case of loss-aversion a loss may be experienced worse if losing $50.000 and this loss forces you to sell your house and move into a less attractive one. In other words, a marginal loss may increase his loss aversion. The first example violates the pattern of decreased marginal value for additional money. The second example contradicts decreased loss aversion below the reference point.

An outstanding feature regarding attitudes of changes in wealth is that losses seem to soar higher than do gains. That is, the displeasure losing a sum of money seems to be greater than winning an identical sized amount. As a consequence people tend to reject a fair and symmetric bet such as ($\$100, 0.50; \$-100, 0.50$). This is the loss-aversion, where an equal sized loss is experienced worse than an equally sized gain. In other words, losing $100 yields more displeasure than gaining $100 yields pleasure. Thus, you fear losses more than gains and this feature creates the aversion to lose. To put it different, people should prefer a status quo over a symmetric gamble. This implies that the value function is steeper in the region of losses than of gains.[13]

To summarize, prospect theory constructs a value function that shows three fundamental characteristics. First, the value is defined in relation to a reference-point and more importantly, deviations away from that point. Second, a general principle that says: concavity for gains and convexity for losses. At last, losses are steeper than are gains.

### 3.1.2 The Weight

The value of each feasible outcome is associated with a decision weight. However, these weights are not to be regarded as "pure" probabilities or beliefs. Instead

[13] Assume $x > y \geq 0$ under following gambles: $(y, 0.50; -y, 0.50)$ and $(x, 0.50; -x, 0.50)$. Using equation (1) yields: $v(y) + v(-y) > v(x) + v(-x)$ and $v(-y) - v(-x) > v(x) - v(y)$. If $y = 0$, $v(x) < -v(-x)$ and if $y \to x$ gives $v'(x) < v'(-x)$. This renders a value function that is more sloping in the loss-region than that of gain.

they reflect the impact of events regarding the prospect's desirability (ibid.). For example, the weights of tossing a coin ($50 - 50$ gamble) might be viewed as less than a 50% chance to get the desirable outcome.

The weighting function $\pi$, whose weights correspond to stated probabilities, is perfect in the final end-points i.e., $\pi(0) = 0$ and $\pi(1) = 1$. Hence, an impossible event is ignored and a certain event is regarded as sure and logically $\pi$ is an increasing function of the stated probability $p$. In general very small probabilities are overweighed in this function i.e., $\pi(p)>p$ given small $p$. KT launch following choice problems in order to explain:

($\$5000, 0.001$) or ($\$5$) for sure

$N = 72$, 72% preferred the first gamble.

($\$-5000, 0.001$) or ($\$-5$) for sure

83% preferred the second alternative

In the first case, people prefer to participate in a lottery to win \$5000 by a very small chance by giving up \$5. This amount could be seen as the lottery price. In the second case, people seem to be prone to buy an insurance protection for \$5 against a bad outcome of $\$-5000$. This is in accordance to previous results of concavity for gains and convexity for losses. To conclude, you are ready to gamble with small money to gain big. Conversely, you are prepared to pay a modest premium to avoid the risk of losing big.

The distinction between overweighting regarding decision and overestimation, referring to likelihood, is significant in the context of prospect theory. The problem with overestimation is solved through the assumption that estimations always equal the stated probabilities of $p$. Despite, the overweighting feature $\pi(p)>p$ for small $p$.

However, prospect theory suggests that for all $p$ following relationship is valid: $1>p>0$ and $\pi(p)+\pi(1-p)<1$. In other words, underestimation for $p$ occurs except very small probabilities. With $\pi \in (0, 1)$, i.e., the interval of probability and decision weight, following figure is constructed:

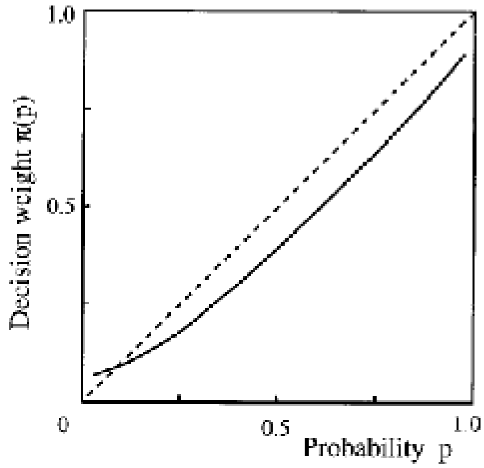


Figure 3.2- Prospect Theory's Weighting function.

In above figure the slope of the decision weight $\pi$ (solid line) represents the elasticity of preferences in relation to changes in probability $p$. Here, preferences in large are less sensitive to changes in probability than the dashed line of expected utility would predict. This is also known as the subcertainty effect.

Apparently, the sum of the weights regarding additional events are less than those associated with a sure event. Furthermore, subproportionality reflects that for a given proportion of probabilities, the attached decision weights are closer to unity for low $p$ than for high. Subproportionality and overweighting jointly render a subadditive $\pi$. That is, $\pi(rp) > r\pi(p)$ for $0 < r < 1$(ibid.).[14]

In general, figure 3.2 represents a function that shows overweighting and subaddtivity for low $p$. Also, it satisfies the properties of subcertainty and subproportionality. Together, these features construct an almost linear function in the open interval. However, it changes behavior dramatically when it moves towards the end-points. In sum, the function behaves "nice and smooth" in the open range of $(0,1)$. However, by including the closed interval of $[0,1]$ it behaves revolutionary different, as the solid line depicts.

This nonlinearity reflects the difficulty associated with attaching decision weights to an event of infinitesimal likelihood or an approximate certain event.[15]

[14] Provided $\pi(p) > p$ and subproportionality $\Rightarrow \pi(rp) > r\pi(p), 0 < r < 1$, under the assumptions $\pi$ is monotonic and continuous over the relevant range i.e.,$(0,1)$.

[15] A compelling and interesting analogy with respect to nonlinearity is the case of Russian roulette. One could elicit the Willingness To Pay (WTP) in discrete levels, ranging from an empty gun to a full-loaded revolver i.e., 6 bullets. A six-bullet gun results in a certain death or loss of health. The assumption is that your WTP on the margin is very high to reduce from 6 to 5 bullets or from 1 to 0 (end-point bullets), than from say 3 to 2 bullets. In the first case you pay to avoid and substitute a certain death by a 1/6 chance to live. In the second you pay to avoid a 1/6 risk to die in order to survive the game for sure.

This gamble represents decision weights in a practical example and how they deviate from objective probabilities, where each bullet is to be regarded as a linear 1/6-probability. However, an individual's mental weighting of each bullet differs significantly from that of linearity, especially in the cases of end-point bullets.

The latter reflects the problem of subtle differences between near certain and certain event. That is, when close certainty approaches certainty, people tend to treat these events as if they were certain or ignore the difference (ibid.). In other words, a 99% chance is perceived as a 100% chance.

In the case of extremely low probabilities, a two-fold strategy is common. First, the perception of utterly slim probabilities results in ignorance e.g., a very unlikely lethal car accident might be totally overseen. Second, the attached decision weights are overestimated compared to stated probabilities, as in the case of purchasing a lottery ticket. This mental overweighting effect might motivate people to buy such tickets despite an unfair gamble. That is, when the overall ticket prices exceed the overall pay-back of the lottery.

In sum, this creates the "weird" behavior of $\pi$ close to its end-points, making it impossible for the weighting function to give a meaningful representation.

### 3.1.3 Reference Point Adjustment

The reference point has so far been treated as status quo. However, there are examples of expected gains and losses that diverge from the status quo-level. For example, a company that announces less loss than expected might perceive this loss as a gain compared to expected outcome, since true outcome beats the expected outcome i.e., the reference level.[16]

To illustrate, consider a gambler who has already lost \$100 and now have an even chance to win \$100 or lose another \$100. If the player has not adapted the first loss of \$100 he is likely to view the second gamble as $(\$-200, 0.50)$ and $(\$0, 0.50)$ rather than $(\$-100, 0.50)$ and $(\$100, 0.50)$. The former representation has an unadjusted reference point at $\$-100$, which according to the value function implies risk prone behavior. In this background, the gambler is prepared to gamble in order to avoid the loss of \$200. However, now assume the same gamble is regarded from a reference level at \$0. In this surrounding, the prospect should be rejected since a symmetric bet at an adjusted reference point at \$0 implies risk aversion. In sum, this illustrates the consequences if the reference point is adjusted to real economic circumstances or not.

Odean (1998a) shows that investors are reluctant to realize their security-losses, where they hang on to losers and sell winners. However, the profitable strategy is shown to be the reverse. These findings support that an unadjusted reference point might lead to a worse-off situation for the investor compared to an adjusted. This behavior seems to be applicable into gambling as well, which I will address further in the analysis.

[16] This psychological concept will be discussed in the chapter of disappointment.

# 4 Regret Criticism

In the early 1980's a couple of important behavioral papers were published, Bell (1982) and Loomes and Sugden (1982). The first paper proposes a regret factor under uncertainty and shows systematic violations of expected utility.

This regret component captures the consequences that the decision maker wants to avoid having made the wrong decision, although the decision seemed to be correct given available information at that time. This is the regret the individual has to bear in mind literally, and which he logically wants to avoid. This could be seen as a psychological alternative cost that causes the individual regret if the factual decision is evaluated less attractive than an alternative possible at that time. The regret factor also embraces psychological feel-good attributes as euphoria and increased self-confidence following a benign decision. Furthermore, every decision consequence has two variables measuring satisfaction i.e., monetary assets and a quantity of regret. The second paper contains a regret/rejoice function.

The standard example criticizing the expected utility model is the well-known Allais paradox, which also is used in this context. The gamble once again:

$$(\$5 million, 0.10; \$1 million, 0.89; \$0, 0.01) \qquad \text{or} \qquad (\$1 million, 1.00)$$

The majority would choose the sure outcome. However, a majority would in a second gamble prefer:

$$(\$5 million, 0.10; \$0, 0.90) \qquad \text{to} \qquad (\$1 million, 0.11; \$0, 0.89)$$

The first choice rendering: $u(1) > 0.10(5) + 0.89u(1) + 0.01(0)$
The second choice rendering: $0.10u(5) + 0.90u(0) > 0.11u(1) + 0.89(0)$

Hence, these two inequalities contradict each other if using utility functions according to expected utility.

However, the paradoxical result above can be represented by a decision regret component. That is, the individual would have severe difficulties to forgive himself if the outcome of the gamble would be that of \$0. In other words, the psychological negative pay-off would be so burdensome that he hardly in the short run could be able to find a mental truce for himself. Logically, this possible catastrophic outcome has to be eliminated. This is due to the regret the individual would feel if he chose the gamble embracing the risk of 1%, instead of choosing the known outcome. This regret factor could be viewed as a mental trade-off, where the individual pays a "price" to avoid carrying the risk of 1% rendering nothing. This would be analogical to that of purchasing insurance in order to avoid the mental worry implied by carrying the risk or worse, that the 1% risk becomes the true state of the world. However, hardly any such effect exists in the second choice problem. Here, the 89% or 90% risk of a nil-outcome is discounted into people's mind and thus expected. Hence, the possible regret effect is very slim or does not exist at all.

The use of psychological regret is in Hogarth (1980). However, Bell (1982) uses a wider definition of regret, decision regret, also including non-mental causes. Here, regret is defined as the difference between the factual return and the maximum return by counterfactual choices.

## 4.1 The Model

Bell (1982) introduces a utility theory where the actual assets the individual obtains are represented by $(X)$. The level he has given up as a result of the made decision, that is to make $X$ to come true, is represented by $(Y)$. In this context $Y$ is labeled forgone assets, which is an alternative cost to $X$. To simplify, if $Y$ is greater than $X$ the individual would experience regret since the alternative would have made him better-off.

The utility function, $u(x, y)$, is positively related to $x$ and negatively to $y$. Assume an outcome, $O$, will come true with probability $p$ leading to final assets of $x_1$ under the first alternative and $x_3$ under the second alternative, and with corresponding asset positions $x_2$ and $x_4$ if not $O$ occurs. By necessity, the first alternative is chosen iff:

$$pu(x_1, x_3) + (1 - p)u(x_2, x_4) > pu(x_3, x_1) + (1 - p)u(x_4, x_2)$$

This is in line with the assumption of foregone assets reflecting regret. This means that regret is associated with assets gained compared to those given up. Those assets given up could be valued higher than those gained. This would create a feeling of regret.

Moreover regret is assumed to be related to a reference point. To illustrate, a final asset position of \$5000 and a foregone asset position of \$6000 would generate a greater feeling of regret than a final position of \$50.000 and a foregone position of \$51.000. Logically, there has to be a larger absolute increase when having a greater/higher reference point or final asset position to compensate for the assumed concavity of the value function. In other words, if all feasible final asset positions and all foregone asset positions are changed by amounts equal to the marginal value, the relations are unchanged. In above example a foregone asset of say \$55.000 compared to final position of \$50.000 may cause the same amount of regret as does \$6000 compared to a final position of \$5000. This is in line with the reference point under prospect theory.

Consider a value function, $v(x)$, which captures satisfaction derived from final assets, and $v(x) - v(y)$ reflects rejoice (if positive) or regret (if negative). Imagine an individual who is indifferent between the lottery $(\$500, 0.50; \$0, 0.50)$ and \$100 for sure. This implies that the, with a 50% chance, additional \$400 from the certain point of \$100 to \$500 is the gambler's *risk premium.* This compensates the possible regret, of 50% risk to lose \$100.[17]

[17] See Bell (1983) for a thorough understanding. He uses a terminology of value equivalent, selling price, cancellation price, resolution premium and regret premium, when describing regret as a factor reflecting risk aversion.

Loomes and Sugden (1982) introduce a ”choiceless” utility function, $C(\cdot)$. That is, a utility derived from a choice $C(x)$ that has been laid upon people by force e.g., through a natural disaster as a cyclone or by political dictatorship. The consequence experienced is represented by $(x)$. Here, utility is defined as the psychological experience of pleasure attached to the satisfaction of desire. To put it different, higher desire associated with a factual outcome gives a higher satisfaction, which gives a higher psychological pay-off. This return is then transformed into terms of utility.

Now allow for choices. Assume the economic agent chooses action $\mathrm{A}_i$ over $\mathrm{A}_k$ and that the $j$th state of the world comes true. The utility experienced hereto is $c_{ij}$, if he had chosen $\mathrm{A}_k$ the utility experienced would be $c_{kj}$. Under the regret-rejoice regime a modified utility function is formulated:

$$m_{ij}^k = M(c_{ij}, c_{kj})$$

where $m_{ij}^k$ represents modified utility, $M(\cdot)$ attaches a valued index or weight to every pair of utility indices. The discrepancy between $m_{ij}^k$ and $c_{ij}$ could be treated as a negative or positive marginal utility related to the surprise of regret or rejoice. Moreover, the sensation of regret and rejoice in this model is associated with the utility of the actual outcome, and what might have been instead.

Regret is, other things being equal, defined: $\partial m_{ij}^k / \partial c_{kj} \leq 0$. That is, the mental experience emanating from the insight that his welfare position would have been better if he had chosen differently. Rejoice is likewise defined: $\partial m_{ij}^k / \partial c_{ij} > 0$. That is, the pleasure associated with the insight that he made the right decision and that he would have been in a worse welfare position if chosen differently. These two consequences are evaluated in the modified utility function. If assuming $c_{ij} = c_{kj}$ then follows that $m_{ij}^k = c_{ij}$, since there is no sensation generating regret or rejoice. This would be a psychological break-even where the outcome neither causes regret nor rejoice. This is related to disappointment theory which is introduced in the next following chapter.

Moreover, a specified regret-rejoice function is defined:

$$m_{ij}^k = c_{ij} + R(c_{ij} - c_{kj})$$

where $R(\cdot)$ is the regret function, attaching a valued index to every feasible (marginal) increase or decrease of utility and $R(\cdot)$ is non-decreasing. In this case strictly increasing, following $M(\cdot)$(ibid.).

The overall aim of this regret model is the maximization of expected modified utility. This differs from the traditional model insofar that it allows for and takes into account people exposing themselves to regret and rejoice.

# 5 Disappointment Criticism

The disappointment theory was introduced by Bell (1985) and Loomes and Sugden (1986). The focal point in the development of disappointment is that people create expectations regarding uncertain gambles or future events. If these events turn out to be worse or better than expected the agent is said to experience a sensation of disappointment or elation.

The disappointment model captures the remaining part that cannot be explained by regret alone. Although, both theories share the same theoretical foundation, disappointment explains some parts of human behavior that are not covered by previous theories. Hence, the disappointment model was developed as a complement and not a rival to regret.

## 5.1 The Model

When people consider an uncertain prospect or gamble they form some, ex ante, or prior expectation about the outcome. That is, they discount some expected utility from that prospect into present time. When the outcome is known the agent is supposed to experience a particular consequence of the gamble. Whether this consequence is worse or better than expected it creates a feeling of disappointment or elation. This influences the overall utility function, negatively if disappointment occurs and positively if elation.

Loomes and Sugden (1986) measure prior expectations of $A_i$, where $A$ is an action of the $i$th prospect, and the probability that some state, here the $j$th state, will become true is $p_j$, $0 \prec p_j \leqq 1$ and where $\sum_{j=1}^{n} p_j = 1$. The consequence of the $i$th action is $x_{ij}$ and there is a basic utility function $C(\cdot)$. The utility from a consequence $x_{ij}$, is measured by $c_{ij}$. This component reflects an ex post utility emanated from any consequence in any circumstance where disappointment and elation do not exist (ibid.). There is a value of expected basic utility $\sum_{j=1}^{n} p_j c_{ij}$, which is denoted $\bar{c}_i$. The component capturing disappointment and elation is denoted as a function $D(\cdot)$. This, on the margin, adds or subtracts utility to the amount of utility derived from the outcome itself, by disappointment or elation via $c_{ij} - \bar{c}_i$. That is, the difference between the basic utility of the actual outcome and the prior expectation. In other words, disappointment is measured as the difference between ex post and ex ante. This difference adjusts the basic utility of any consequence in an action. The modified overall experienced utility given the $j$th state is $c_{ij} + D(c_{ij} - \bar{c}_i)$. The expected modified utility of the $i$th action is labeled $E_i$ where:

$$E_i = \sum_{j=1}^{n} p_j [c_{ij} + D(c_{ij} - \bar{c}_i)]$$

this says that people try to predict any disappointment or elation that can arise. Consistently, they aim for maximization of the expected modified utility.

Some restriction are imposed on the curvature of $D(\cdot)$. Of course, disappointment is experienced negatively whilst elation is pleasurable. Together they postulate that $D(c_{ij} - \bar{c}_i) \gtreqqless 0 \Leftrightarrow c_{ij} - \bar{c}_i \gtreqqless 0$. If $D(0) = 0$ i.e., a choice under certainty, the individual is assumed to only maximize basic utility. Furthermore, the amount of disappointment is a non-decreasing function of the negative difference between the outcome and former expectations i.e., $D'(c_{ij} - \bar{c}_i) \geqq 0$. Expected utility would be applicable if $D(\cdot)$ showed linearity. However, the disappointment model assumes nonlinearity. That is, $D(c_{ij} - \bar{c}_i)$ is said to be convex in the area where $c_{ij} - \bar{c}_i$ is positive, and conversely concave when $c_{ij} - \bar{c}_i$ is negative. These properties give the following function:

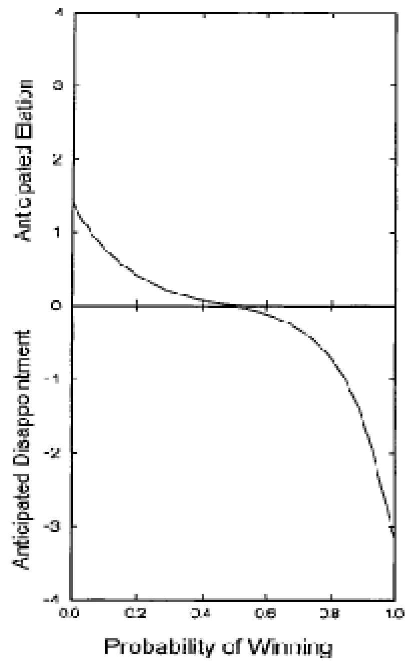


Figure 5.1- A Disappointment function.

The above figure states that if an unexpected good outcome (low $p$) occurs there is a great elation. If there is an expected good outcome (high $p$) not occurring there is a great disappointment. Generally, if $p$ decreases there is an increased marginal anticipated elation when $p$ is less than 0.5, and if $p$ increases there is a decreased marginal anticipated disappointment when $p$ is greater than 0.5. Hence, the function is concave for disappointment and convex for elation.

Bell (1985) introduces a simple disappointment model under the lottery with probability $p$ rendering \$$x$ and the remaining probability $(1-p)$ generating \$$y$. The individual's expectations may be represented by the amount $px + (1-p)y$. This gamble is denoted $(x, y, p)$ where $x \geq y$ and $p$ is the probability of winning. If $y$ is the actual outcome, the individual will experience disappointment ($D$) in proportion to the difference between expectation and actual outcome:

$$D = d(px + (1-p)y - y) = dp(x - y) \tag{3}$$

where $d \geq 0$ is a constant representing the degree to which a unit of disappointment impacts the individual. However, if $x$ occurs ($x>y$) then he will experience a feeling of elation ($E$) which is assumed to be in proportion to the difference between ex ante and ex post:

$$E = e(x - px - (1-p)y = e(1-p)(x - y) \tag{4}$$

where $e \geq 0$ is a constant representing the degree to which a unit of elation impacts the individual. Equations (3) and (4) are equal except that $D$ and $E$ are both associated with positive values, although they capture opposite feelings. Moreover, the constants $d$ and $e$, representing trade-offs for the individual between amounts of \$ and the psychological welfare, can differ. The simple Bell model assumes that people's utility over \$ and $D$ or $E$ is linear and additive (ibid). That is, the overall utility equals economic pay-off plus mental pay-off. Of course, $D$ is negative mental pay-off whereas $E$ is positive.

However, assume that one effect of $D$ or $E$ exceeds the other e.g., disappointment is a worse experience than is elation. Given this the certainty equivalent of a gamble $(x, p, y)$ is:

$$px + (1-p)y + (e-d)p(1-p)(x-y)$$

Despite having assumed constant marginal value for \$, a relative risk aversion to $D$ over $E$ will occur and the individual is said to be risk averse. In this example, disappointment has a greater impact on the total utility than has elation.[18] Gul (1991) shows that disappointment aversion and risk aversion are deeply linked to one another. More precisely, risk aversion implies aversion for disappointment

Noteworthy, the expectations an individual has are highly subjective in the sense that they may differ significantly from man to man and from situation to situation. For example, a person with high self-confidence may evaluate the chance of a favorable outcome higher than does a low self-esteem person. Hence, the psychological shape may form expectations about future events.

Now, consider four various lotteries:

$$(\$10000, 0.10; \$0, 0.90)$$
$$(\$2000, 0.50; \$0, 0.50)$$
$$(\$1111, 0.90; \$0, 0.10)$$
$$(\$1001, 0.999; \$0, 001)$$

If the individual compare these lotteries with an expected value of \$1000 in each case and with the simple-linear disappointment equation (3): the disappointment would be the same in every gamble. However, a negative feeling of receiving nothing may be experienced more or less serious. Probably, most people would feel the heaviest disappointment in the last gamble since the risk for nothing was utterly petite. On the other hand, the winning-prize was the lowest in this case.

The principal problem is to find out whether the amount of disappointment is the same in every four cases or not. There seems to be a higher degree of

[18] I like financial analogy. The compensation (risk-premium or elation in this case) in order to make potential disappointment attractive to hold is, on the margin, more possible elation per unity than disappointment ($e > d$).

This is the certainty equivalent, where the economic agent has to be compensated by an expected positive return (elation) to accept carrying possible negative return (disappointment).

acceptance for losses in bets with high standard deviations (ibid). Conversely, a very low standard deviation as in the fourth lottery would generate serious bad feelings. Logically, the second lottery with a high standard deviation should generate milder negative feelings. Hence, bets with low volatilities might render comprehensive disappointment if negative outcome and vice versa. Therefore, disappointment may not solely be captured by a level of prior expectations. It should also include a component representing the probability that the outcome was realized by. In sum, even if people do not expect to win much it hurts badly to lose when the loss was unexpected.

Furthermore, the satisfaction associated with winning unexpectedly should be greater than that of expected wins. To illustrate, once again, consider four gambles:

$$
\begin{aligned}
&(\$10000, 0.90; \$0, 0.10)\\
&(\$10000, 0.50; \$8000, 0.50)\\
&(\$10000, 0.10; \$8888, 0.90)\\
&(\$10000, 0.001; \$8999, 0.999)
\end{aligned}
$$

All gambles have the same level on the gaining amount i.e., \$10.000, and an expected value of \$9000. According to the simple-linear elation equation (4) all gambles would be equally desirable. Plausibly, most people would regard the last gamble as associated with highest degree of elation since it is constructed with the smallest chance for a benign outcome. To summarize, people tend to have a higher intensity of elation when the odds were speaking against a pleasurable outcome.

# 6 Analytical Discussion

In this chapter I will analytically address reference dependence, disappointment protection, gambling and gambling addiction applied to relevant theories.

## 6.1 Reference Dependence

Prospect theory is constructed upon the fundamental assumption that human perception is reference dependent. In a psychological context perceived attributes, of a certain thing in focus, generate a set of stimuli. This set creates a reference value to which other events are dependent on.

An illustrative example would be a medical examination for cancer. Stimuli associated hereto would probably create negative feelings because of the risk to receive an answer that you really got cancer. Further assume that these stimuli are compared to prior experiences. These could be that relatives of yours have died in cancer. In addition, there are present parallel stimuli influencing the overall picture. For instance, a fear that perceived good friends will ignore you because they do not know how to tackle the situation. In this case, a strong pessimistic reference level would be that you got cancer and some of your tight friends have abandoned you. Given this background, say that you close in time receive the information that you have won $1.000.000 in a lottery. This gain is likely to be treated as less favorable compared to if you were healthy. To conclude, the reference-point influences the evaluation of other things occurring. In this case, the perceived cancer influences the evaluation of a lottery outcome.

However, standard economics lacks a reference value since it is focused on final states. Thus, the expected utility model is said to be reference independent (Kahneman, 2003a). I think some experiments, following Kahneman (2003b), deserve to be reviewed in order to derive the analytical need for reference dependence in economic analysis.

Consider following prospect:

50% chance to win $150

50% risk to lose $100

In addition: would your decision change if your total wealth sank by $100?
Results say there will be few people accepting this gamble, unless the feasible win is at least twice as big as is the feasible loss with symmetric chances (ibid.). Again, this is the risk premium people require in order to carry uncertainty. Furthermore, the additional question is rejected since the marginal effect of a wealth-decrease by $100 is ignorable to most people.

Now, consider a second prospect:

100% risk to lose $100

or

50% chance to win $50

50% risk to lose $200

In addition: would your decision change if your total wealth were raised by $100?
Empirical results in the second gamble show there is a strong willingness to engage in the bet in order to avoid a sure loss of $100. Here, people possess risk prone preferences since they are ready to gamble in order to avoid a sure loss of $100 with the risk of ending up at $\$-200$. Further they neglect the marginal effect of $100 because another $100 to your accumulated wealth hardly changes your decision made.

To conclude, these two problems illustrate that people change, rather rapidly, from risk avoiding behavior to risk seeking ditto. That is, preferences are decided by attitudes to gains and losses. This defines the reference dependence.

Consider yet another problem: where two persons were informed that their wealth had changed:

Person $A$'s wealth went from $\$4M\ to\ \$3M$

Person $B$'s wealth went from $\$1M\ to\ \$1.1M$

Then two questions were asked:

($i$) Who of the two has more reason to be satisfied with her financial wealth?
($ii$) Who is the happiest today?

According to expected utility person $A$ should be more satisfied than person $B$ due to higher wealth in the final state, since \$3$M$>\$1.1$M$. However, one shortcoming of the EU model is that it does not consider the change in wealth which in $A$'$s$ case is negative (\$4$M$ to \$3$M$) and in $B$'$s$ case is positive (\$1$M$ to \$1.1$M$). In conclusion, behavioral theories say it is hard to separate mental emotions from utility analysis. To put it different, final utility is affected by a psychological utility which is dependent on the reference level the individual perceives. The first question is only focused on the final state. Thus, it ignores the psychological well-being of an additional gain and the mental ill-being of an additional loss which occurred just before the evaluation of the final state.

Now I would like to introduce a health-economic example. Consider two groups of patients treated for amnesia. The first group is treated with placebo i.e., an effect which is measurable or felt like an improvement in health but not associated with the treatment itself. The second group is not treated at all. In terms of final health both groups should experience equivalent changes in health (utility) since the effect of useless pills and no pills should be the same. That is, unchanged health. However, the first group is told that the pills will have a positive effect. This is the reference dependence where the patients' positive attitudes towards a claimed health improvement (higher utility) might foster positive psychological emotions. However, according to predictions by expected utility this treatment would be useless since the final utility of useless pills and no pills should be the same i.e., no utility at all. This illustrates the difference allowing for reference dependence or not.

Another example is that of initial endowments. The standard way to evaluate economic wealth is through final endowments. However, behavioral theories focus on initial endowments. In sum, the microeconomic indifference curves do not embrace initial endowments as the behavioral theories do in the case of reference dependence. This is the endowment effect, where the selling price of an endowed good often is at least twice as big as is the buying price (Kahneman, 2003a). In other words, the intrinsic value of a certain good is higher if it could be viewed as something that could be lost, compared to when the same good is perceived as a gain and to which you are not attached.

A famous illustration is that of mugs. 1/2 of the people participating in an experiment were endowed with mugs. Then trades were allowed. Experimental results point out that there were fewer trades than predicted by expected utility, which assumes initial endowment does not matter. These results suggest that the mugs were not valued as consumable goods. Instead they were perceived as something you could get or lose. This is in accordance to prospect theory because of the required compensation to accept losing a mug is greater than the willingness to pay for a mug. Thus, there is concavity for gaining the mug and convexity for losing it. This explains the difference between the selling price and the buying price. Furthermore, this contradicts a fundamental assumption in economics. That is, the selling price should in equilibrium equal the buying price in order to clear the market.

### 6.2 Disappointment Protection

Disappointment can be viewed as if the actual outcome underperforms compared to the anticipated level. According to van Dijk *et al.* (2003) there are two protective strategies against possible disappointment.(*i*) Ensure that actual outcome does not go below the level set by your expectations.(*ii*) Lower your expectations if it is likely that you will not meet the desired level of the outcome. The former strategy might be difficult to live up to, whereas the latter might be more realistic to apply. That is, people lower their expectations when they fear failure in order to protect against a disappointing less-than-expected outcome.[19]

Once again, consider the medical test for cancer. Here the individual might apply a two-fold protection strategy. First, an extrovert strategy which is pure pessimistic and assumes you got cancer. This is the official version told to other people. Second, an introvert and optimistic strategy that assumes you do not have cancer. This is the unofficial version not told to other people. The latter strategy seems more reasonable that people actually use as expectation level. Another example would be if applying for a scholarship, where you might adopt a similar two-fold strategy. Extrovertly, you do not expect to get the scholarship. By introspection, you have higher expectations to get the scholarship. These are examples of revealed and unrevealed levels of expectations. The revealed level protects against feasible disappointment and the unrevealed does not.

However, people do not always underestimate their chances. There are mainly two variables deciding if this strategy might be useful. The first factor is the degree of self-relevance of the consequence associated with the outcome. That is, there are stronger arguments to lower expectations if the consequence affects one's own mental well-being. The second factor involves a temporal aspect where feedback plays a crucial role. This reveals whether an outcome is reached or not. Given feedback is relatively distant in time people tend not to lower expectations as much as they do when the evaluation is immediate (ibid.). To conclude, a way to protect against close-in-time feedback is to lower expectations.

For instance, students who were about to take an exam close in time were less confident scoring high than were students taking the exam in four weeks (ibid.). Another example is when college students were asked about their belief regarding their entrance salary at their first full-time job. Students close to graduation seemed to be relatively pessimistic than were students remote from graduation. A third illustrative case is that patients diagnosed for medical diseases were less optimistic when learning about their results very soon in time. This would be in line with my own cancer-medical example where pessimism in the short run might be far stronger than optimism.

[19] Another version of disappointment protection is defensive pessimism, which also embraces a behavioral component lowering expectations.

In conclusion, individuals seem to lower their expectations in order to protect against disappointment foremost by two reasons. First, if an outcome with self-relevant meaning is expected. Second, the temporal dimension which is dependant on if the feedback is close in time. These two create incentives to hold down expectations to escape possible disappointment and logically to increase the possibility for elation.

## 6.3 Gambling and Gambling Addiction

Many studies have searched for good and relevant explanations to why some people are caught into gambling. Bell (1982) refers to an entertainment value for modest gamblers. However, in particular interest is those who despite several systematic losses continue to bet as if they were addictive upon gambling. Here the expected utility does not apply and rational arguments seem to be out of order so to speak.

Gambling behavior could be represented by a regret component. For instance you might play the lotto to avoid the potential regret of not having gambled. To illustrate, assume a great positive outcome occurs on your number you usually bet on but you did not gamble. Then the feeling of remorse would probably be intense. This hypothesis says that the individual engages in an economic activity perhaps not to win but to protect himself from worry or potential regret that he would have won if he had participated, but did not.

In a lotto-case where you recently changed numbers, a gain on your old numbers would be perceived as a loss, despite the fact that you only lost the betted money. To illustrate, the cost of participating in lotto is set to \$5 with a feasible pay-off of \$100.000. Assume that you would have won \$100.000 if you had gambled on your prior numbers, but you did not. The reference point would probably treat this as a loss of \$100.000 and not as an ignorable loss of \$5. That is, the reference point creates the regret the individual experiences due to the strong negative psychological mood this loss inflicts. However, expected utility would treat this as a matter of final states i.e., a loss of betted money. In this case a loss of \$5. I do not think this is a realistic assumption and prediction how people in general will perceive a loss. Especially, if they on a regular basis play the lotto or if they experience a near miss i.e., they were close to win.

Now consider a gambler who has lost a vast amount of money. Instead of realizing his loss i.e., he accepts and confronts his loss and decides to quit gambling, he continues to gamble. This could be a token of trying to avoid or postpone facing the regret that he started to gamble and the disappointment that the gamble did not meet his pay-off expectations. To explain, consider a simple two-period model. In the first period, the gambler quit gambling and realizes his loss. That is, his wealth ($w$) is subtracted by his realized loss ($x$). This gives us the gambler's new asset position $w-x$. However, he tries to regain his prior welfare of $w$ by continuing to gamble. Assume he will continue to lose money. This will render him a worse-off situation of $w - x - y$ where you can assume that $y>x$. In other words, his wealth has shrunken more in absolute terms than the first period since $y>x$. In the extreme case he will continue to gamble till his $w$ moves towards bankruptcy. That is, $w - x - y - z = 0$ and $z > y > x$, where $z$ captures all the residual amount of lost money. In other words, the second period is a race to the bottom where the gambler does not quit until he is deprived of all his wealth. Foremost, this gambling behavior is explained by psychological factors that prevent him to realize his losses as long there is an utterly petite chance to recover to $w$. This is the *gambling trap*, which destroys his wealth due to increased risk taking after every loss, where the risk seeking behavior in the end is desperate. I think gambling addiction is applicable to this model. Whilst occasional or modest gamblers probably will accept their losses and avoid being trapped, addictive serial gamblers deny their losses and continue to gamble.[20] This would explain why some people continue to gamble, despite repetitive losses. In other words, once you have started it might be difficult to quit gambling. This constitutes the trap. However, it is not perfectly clear why some people start to gamble whilst others do not. That question is beyond the scope of this thesis.

Another version of the trap-problem would be the game even or double. Assume you recently lost \$100 at a trivial coin-tossing gamble, where you gain \$100 if head occurs and if tail then \$100 is subtracted to your wealth. Here, some people seem to be willing to accept a gamble that if you lose, deprives your welfare more than a gain would improve it. Since the loss aversion states that losing \$100 renders more disutility than the utility associated with an equivalent gain would do. Normally, you would not accept such a gamble. However, the gambler's psychological attention is to regain prior level of welfare. This behavioral property is labeled framing effect. This effect implies that people are ready to gamble with quite severe possible consequences in order to catch up to prior asset position because they do not fully consider the option that they might continue to lose money. That is, to restore a neutral balance of \$0 which in the short term is preferred to accepting a loss of \$100 and quit gambling. This gambling behavior reveals that people do not rationally embrace the possibility of a bad outcome i.e., losing another \$100 and an aggregated negative balance of \$200. The assumption of rationality would predict complete consideration of this negative option. However, the short-run gambling desire to equalize the \$100-loss is more intense than to give up gambling and accept the loss. From a behavioral aspect, losses seem to cause a great amount of negative mental payoff and regret. Hence, the agent is prepared to get rid of his mental anxiety by accepting that his welfare at a 50% risk is worsened furthermore by losing another \$100.

The aspect of cognitive psychology emphasizes a component of cognitive bias into gambling. This component embraces human behavior such as illusion of control, biased evaluations and cognitive regret (Griffiths, 1990). The illusion of control contains an erroneous element that personal skills contribute to fa-

[20] This model may explain other addictions as alcoholism and food abuse. The drinker continues to drink because he is reluctant to realize he is an alcoholic, and the eater continues to eat due to similar reasons.

This might be a good policy-argument for politicians in favor of regulated markets for alcohol and gambling.

vorable outcomes, when pure luck is the only thing in control. Dice-playing, slot machines and coin-tossing are examples of illusion of control where the economic agent systematically believes that his hand can do better than can others.[21] Therefore, a regret component is represented by letting anyone else running the gamble when the strong belief is that you can outperform the average gambler in a gamble based solely on chance. Moreover, there seems to be a tendency amongst people to explain away losses or perceive them as ”near wins” i.e., only if ”that” had occurred I would have won (ibid.). This seems to be a way of motivating further gambling, because there is a strong belief that next time will be more profitable. Hereby, a series of losses can be perceived as an aggregated coming chance to win.

Above behavior is nicely explained by the gambler's fallacy. To illustrate, when playing the roulette and considering betting on red or black color you might be more prone to bet on black if red just recently occurred four times in a row. Despite the statistical fact that black verses red always is an equiprobable 50-50 chance regardless recent outcomes.[22] These evaluations are biased because they are based upon the next time syndrome, where the player thinks he deserves to win, if not now so next time. This defines the fallacy.

In a gambling context, the value function of prospect theory is highly relevant. The convexity for losses seems to foster increased risk taking, trying to compensate for recent losses with gains and the gambler accepts gambles he hardly would accept otherwise. This is not consistent with the assumption of stable preferences over time. Furthermore, it violates one of the expected utility core assumptions that risk preferences are insensitive to changes in wealth. Clearly, gambling and persistent gambling changes the individual's risk preferences due to changes in wealth. If the gambler loses money he might accept prospects with higher risk e.g., so called long shots with high odds and logically low probability to win in order to equalize losses. Alternatively, he could accept a gamble with low odds but with higher stakes. To explain, betting on a horse which renders 1.10 the betted money could compensate prior losses if the betted amount is large enough. Assume a player with a loss of \$1000 so far a given day at horse tracks. This loss of \$1000 could be compensated by a larger stake. If the horse wins at the 1.10 odds, a betted amount of \$10.000 will compensate the prior loss of \$1000 since the net winning amount is $0.10 \times \$10.000 = \$1000$. However, playing with \$10.000 when the aggregated intra-day loss is 1/10 of that seems adventurous. Probably, the gambler would not be willing to accept this gamble if his intra-day loss was \$100. In other words, the greater the magnitude of the loss is some gamblers are willing to carry more risk than they normally would do to equalize losses.

Many gamblers seem to cognitively treat gains in a different manner than they do losses. Gained money is usually divided into two separate mental ac-

[21] Odean (1998b) shows that traders in financial markets in general are overconfident and perceive themselves to be better informed. That is, they underestimate other traders' chances to perform equally well. This should be applicable into gambling as well.

[22] In other words, the chance has no memory!

counts.[23] The first account contains the amount of money before reaching a level of satisficing.[24] The second account contains the money exceeding this level. As an illustration, Camerer *et al.* (1997) show how cabdrivers in New York City seem to operate against per day income-targets, where these targets are the satisficing levels. When this goal is fulfilled the marginal value of additional money seems to drop to zero, since the drivers do not really care about taxi-money exceeding that daily target.

Analogically, gamblers would treat gain-money up to a subjectively decided level of say $100 seriously. However, money exceeding that level is placed into a 'high-risk' account with more speculative and aggressive bets. Hence, the cognitive sense of losing money would be less severe if lost money emanates from a gain account than money from other accounts. This behavioral feature violates two principles of standard economics. First, that risk preferences are stable. Second, is the principle of fungibility.[25] In sum, dollars belonging to the first account seem more precious than dollars belonging to the second account. The standard assumption of decreasing utility for money can hardly explain this since the utility seems to drop very sharp at some subjective point as in the cab-example.

Ladd and Petry (2002) evaluate gambling behaviors, including online gambling. Their findings show that people who gamble online are more likely to have gambling disorders than others. Moreover, it seems that online gambling fosters repetitive patterns, and people betting online are more likely to belong to the group of addictive gamblers than are other gamblers. Barber and Odean (2002) show that online investors after going online, systematically perform worse than before and that they trade more often, more speculatively and more aggressively. Hence, one might conclude that online-accessibility also triggers increased gambling. In sum, this might change a gambler's risk preferences and make him more risk prone than before.

However, there are other dimensions into gambling than economic and psychological factors. A biological perspective distinguishes between causal social gambling and pathological gambling. The former is mainly driven by an entertainment value whereas the latter contains disorder of impulse control. In a neurobiological perspective gambling addiction triggers an increased level of dopamine in the brain (Powledge, 1999). This generates a sense of well-being and motivates further gambling.[26] Shiv *et al.* (2005) point out that people with

[23] Following Thaler (1999) a mental account is defined as a set of cognitive operations used by people to keep track, evaluate and organize their financial activities.

[24] The term satisficing represents a behavior which attempts to reach at least some minimum level of a given variable, but not its maximum possible value. This is the satisficing level.

[25] Fungibility measures how easily a given good could be exchanged for another example of an identical good at an equal value.

Trivial examples would be those of gasoline and gold. To illustrate, a gallon of gasoline should be exchangeable for another gallon of identical gasoline.

In a gambling background one betted $ should be of identical value of another betted $.

[26] This might be relevant to neuroeconomics, which is an interdisciplinary approach of neuroscience, economics and psychology.

neural dysfunctions or decreased emotional reactions made more money from their investment decisions than did normal. When normal people gained or lost money they became more risk averse, whereas the dysfunctional averaged a relatively more risk seeking attitude.

# 7 Concluding Comments

This thesis' main ambition has been to introduce, scrutinize and compare behavioral theories to standard economics. To be more concrete, behavioral variables such as loss aversion and reference dependence have trigged a theoretical discussion if economic utility is correctly understood by only considering final outcomes. These two concepts are of fundamental importance to behavioral theory. As a consequence, I have discussed and analyzed reference dependence and the related loss aversion and how they more accurately might represent an economic agent. Here, the final utility is affected by an associated behavioral utility which is dependent on a reference level that the individual perceives. More important, this utility is assumed to influence the final utility. In accordance to this, regret and disappointment have been rather successful to capture human economic behavior ignored by expected utility.

The regret and disappointment theories represent people's experiences when their decisions turn out to be wrong or worse than expected. In the case of regret, an alternative decision would have rendered higher utility. In the case of disappointment, the actual outcome does not meet expectations. In both cases the psychological reaction has a negative impact on the final utility.

Regarding persistent gambling I find psychological approaches fruitful. In conclusion, gambling and possible addiction could be explained by regret, disappointment and increased risk taking. This gambling trap reflects why some people have a hard time to quit gambling. However, most people seem to be able to handle their betting at a moderate level. Also, there is an accessibility dimension which predicts increased and more aggressive gambling when going online. Furthermore, gamblers are willing to engage in gambles they normally would not accept. This might be due to behavioral phenomena like framing effects, gambler's fallacy and mental accounts.

To summarize, expected utility does not consider psychological aspects of utility in economic decision-making. Hence, changes in human emotions as happiness, regret or disappointment emanating from unexpected gains or losses are ignored. These additional perspectives might in a better way reflect how people, descriptively, behave and how they, prescriptively, will behave concerning uncertain economic choices. Because of ignoring these changes in psychological attitude may lead to incorrect representations of how utility really is experienced and perceived.

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