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BEHAVIORAL DECISION THEORY: INSIGHTS AND APPLICATIONS

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Abstract

This paper provides a selective overview of the current state of descriptive models of decision and choice. It first contrasts psychological and behavioral-economic approaches, and summarizes some psychological insights that should be useful in giving economic decision and choice models more descriptive power. The paper then provides an overview of two recent developments in behavioral decision theory: (a) descriptive non-expected utility models, in particular, rank-dependent utility theory and risk-value models with new definitions of riskiness; (b) decision rules that are different from utility maximization, in particular, reason-based choice and explanation-based choice.

1. Descriptive decision modelling in psychology and economics

Over the last few decades, psychologists and, more hesitantly, economists have been paying closer attention to the behavioral assumptions that underlie theories about the decisions and choices made by individual actors. In 1957, Milton Friedman argued that the reality of a theory's behavioral assumptions was immaterial, as long as the theory predicted observed behaviour correctly. It has been unfortunate for logical positivism that economists have been unable to explain many phenomena in macroeconomics (e.g., the absence of adequate voluntary retirement saving), labour economics (e.g., the existence of involuntary unemployment), and finance (e.g., the volatility of the stock market) by traditional rational, economic arguments alone, i.e., without recourse to a revision or extension of behavioral assumptions.

The subdiscipline of economics that has concerned itself with such extensions has become known as experimental economics or behavioral economics (see Gilad and Kaish, 1986, for an overview and examples). The subgroup of cognitive and social psychologists who have addressed the adequacy of behavioral assumptions in models of judgment and choice have become known as behavioral decision theorists. While both disciplines address similar issues, they do so from different disciplinary perspectives which affect the focus of their research and their judgments about the relative importance of phenomena, as summarized in Table 1.

TABLE 1. **Comparison of Descriptive Choice Theories in Psychology and Behavioral Economics**

	PSYCHOLOGY	ECONOMICS
FOCUS ON	explaining processes	predicting outcomes
	individual behaviour	aggregate behaviour
	learning	equilibrium solutions
	phenomena	theory
ANOMALIES STUDIED	deviations from normative behaviour	market inefficiencies
PROXY FOR IMPORTANCE	can it lead to preference reversals?	can anybody make money with it?

The descriptive modelling of choice is thus an interdisciplinary enterprise, which has the benefit that researchers from a given discipline can "take away" and utilize established insights from other disciplines. There is much that psychologists can take away from economics. However, since this paper is a contribution from a psychologist to a group of economists, it will emphasize the other set of lessons, namely the insights of psychology that are useful in giving economic decision and choice models more descriptive power. As summarized in Table 2, the first insight is that perception is subjective, with a long history in psychophysics (which is concerned with regularities in the mapping of objective, physical stimuli into subjective perception) and in attribution theory (which is concerned with regularities in people's interpretation of causal relationships). The second insight, that perception is relative, also goes back to psychophysics (e.g., the subjective perception of the temperature of tapwater

depends on whether one's hand has previously been emerged in ice water or in hot water), but has important ramifications for the perception of decision outcomes, as discussed below in Section 2. Allowing for perception to be subjective opens the door to the possibility of individual differences in behaviour. Psychology offers a set of results about the role of stable traits as opposed to situational states in bringing about such individual differences. Finally, there is a literature on intrinsic incentives (e.g., an enjoyment of mastery for its own sake) that motivate people above and beyond the extrinsic incentives usually considered by economists. A more extensive, engaging, recent discussion of these contributions can be found in Plous (1993).

TABLE 2. Economists as "Consumers" of Psychology: Worthwhile Takeaway Insights

(1) Perception Is Subjective
- Psychophysics
- Attribution Theory

(2) Perception Is Relative
- Context Dependencies
- Framing Effects
- Mental Accounts

(3) Theories of Individual Differences
- States vs. Traits

(4) Role of Intrinsic vs. Extrinsic Incentives

The remainder of this paper addresses two recent developments in the descriptive modelling of decision and choice. Section 2 describes models that have been offered as descriptive successors to expected utility theory and involve modifications of the expected utility framework without relinquishing the fundamental assumption that people's goal in choice is the maximization of subjective utility, however defined. Section 3 describes two models that postulate different decision goals.

2 Descriptive non-expected utility models

Rank-Dependent Utility Evaluation

An important contribution of psychology to the study of behaviour, in general, and judgment and decision making, in particular, is its demonstration that experience is relative (e.g., that it depends on context and reference points). Prospect theory (Kahneman & Tversky, 1979) is a formalization of the insight that people tend to perceive outcomes as gains or losses relative to some reference point, i.e., that outcomes are encoded in a sign-dependent fashion (Markovitz, 1959). Recent rank-dependent utility theories in psychology (Tversky & Kahneman, 1992) and economics (Quiggin, 1982; Yaari, 1987) describe another way in which context influences the evaluation of outcomes. The weight that people give to an outcome often depends on its rank in the distribution of other possible outcomes.

In the decision literature, the failure of traditional variants of expected utility (EU) theory to describe a wide range of phenomena observed in people's choices between risky or uncertain alternatives is well documented (see, e.g., Lopes, 1990; Schoemaker, 1982). A variety of non-expected utility models have tried to accommodate these deviations in behaviour from expected utility theory by replacing the model with one that is no longer a linear function of objective probabilities (for reviews see M. Weber and Camerer (1987)). Some of these models have the drawback of predicting violations of the principle of stochastic dominance, i.e., they predict that people would not choose an alternative that is as good or better in all outcomes than another alternative. Such counterintuitive predictions occur when the nonlinear transformations of objective probabilities into subjective decision weights are not sufficiently constrained (e.g., Kahneman & Tversky, 1979). Since stochastic dominance seems to hold empirically or is violated only in very special cases (Lopes, 1984), and since it is useful for economic and other applications by allowing for the comparison of risky decision alternatives in terms of their cumulative distribution functions (Levy, 1992), models that predict violations of the principle are at a disadvantage.

Fortunately, there is a class of non-expected utility models for which stochastic dominance violations do not arise. These models create their nonlinearity in decision weights in a more constrained way, by introducing some dependence between the evaluation of probabilities and characteristics of the outcomes. The rank-dependent utility (RDU) models by Quiggin (1982) and Yaari (1987), for example, achieve the nonlinearity in decision weights necessary to account for people's deviations from EU theory by a nonlinear nondecreasing transformation $\underline{w}$ that operates not on individual probabilities but on the cumulative distribution of outcomes. In their model, the utility of an alternative $\mathbf{X} = (p_1, x_1; \ldots; p_n, x_n)$, with outcomes ordered in increasing order of preference $(u(x_1)<\ldots<u(x_n))$, is defined as

$$RDU(\mathbf{X}) = \Sigma_i \pi(p_i,\mathbf{X})\, u(x_i), \text{ where } \pi(p_i,\mathbf{X}) = w(p_i + .. + p_n) - w(p_{i+1} + .. + p_n).$$

The decision weight $\pi(p_i,\mathbf{X})$ now is a difference between two expressions that no longer depend only on p_i but also on the rank of outcome x_i relative to other outcomes, and thus on the whole distribution of outcomes, $\mathbf{X}$: the first expression is the sum over the probabilities of all outcomes that are at least as great as x_i; the second expression is the sum over the probabilities of all outcomes that are greater than x_i. The dependence on the rank of x_i comes about because different probability values enter into the two summations, depending on the rank of x_i. For a linear $\underline{w}$-function this does not matter, and RDU reduces to the EU model. For nonlinear $\underline{w}$-functions, however, the decision weight $\pi(p_i, \mathbf{X})$ given to probability p_i depends critically on the rank of the associated outcome x_i.

There is strong consensus that rank-dependent utility is the leading candidate for a formalized successor to the expected utility model. Wakker, Erev, and Weber (1994) provided the single axiom that delineates rank-dependent utility from expected-utility maximization (i.e., the comonotonic independence assumption) and described an experimental design to test the axiom that is robust to possible violations of other assumptions (e.g., violations of transitivity).

Psychological Reasons for Rank-Dependent Utility Evaluation

Throughout the 1980s, Lopes (1984, 1987, 1990) provided solid empirical evidence for the fact that individuals differ in the relative emphasis they put on the security level vs. the potential of risky alternatives, and that such differences in perspective affect their choices. The original formalization of the security--potential (SP) aspect of Lopes' SP/A theory (A, for aspirations) in terms of visual characteristics of Lorenz-curves (i.e., cumulative probability and value functions adopted from welfare economics) was perhaps not as tractable and easy to use as the more recent formalization (1990) in terms of the rank-dependent functional. More important than the formalization, however, is the fact that the theory provides a psychological mechanism and justification for the existence of rank-dependence and attempts to explain it as a function of individual and situational variables.

While Lopes (1987) assumed that a person's relative emphasis on the high vs. the low end of the distribution of outcomes was primarily a stable individual difference characteristic, Birnbaum, Coffey, Mellers, and Weiss (1992) showed that differential configural weighting of outcomes can also be induced by the task. People were asked to judge the value of monetary lotteries either from a buyer's, seller's, or neutral perspective. Resulting differences in judgments were best explained by strategic differences in the configural weighting of lower vs. higher ranked outcomes as a function of the assigned perspective with its associated loss function for misvaluations. Buyers of a lottery tended to assign more weight to the lower-ranked outcomes when setting a price, consistent with the interpretation that for them the consequences of overvaluing the lottery (namely, to lose money by receiving an outcome lower than the purchase price) hurt more than the consequences of undervaluing it (namely, to forego money by not purchasing a profitable lottery). Sellers, on the other hand, tended to assign more weight to the higher-ranked outcomes when setting a price, since for them the consequences of undervaluing the lottery (namely, to lose money by selling a profitable lottery too cheaply) hurt more than the consequences of overvaluing it (namely, to forego money by not selling a not-so-profitable lottery).

Weber (1994) argued that these and other phenomena can be explained by the same psychological mechanism. Another phenomenon are biases in the numerical interpretation of verbal expressions of probability (e.g., the probability you infer when a broker tells you that a market correction is "likely"). Probability information often gets communicated verbally. A weatherman forecasts that "rain is likely." A doctor assures her patient that "there is a good chance that the prescribed medication will have no side-effects." Wallsten, Budescu, Rapoport, Zwick, and Forsyth (1986) and Mosteller and Youtz (1990) studied people's perceptions of the numerical probability implied by such verbal expressions. Each expression was found to be interpreted as expressing a range of plausible numerical probabilities, but to varying degrees. Thus people perceive the word "likely" to imply probabilities anywhere between 0.5 and 0.99, with most interpretations around .8 and decreasing frequency of interpretation to both sides.

Verbal expressions have been mapped into numerical estimates for other quantities. For numerical equivalents of expressions of frequency and amount, Bass, Cascio, and O'Connor (1974) found good agreement between judges and no evidence of contextual effects. There is greater variability in people's numerical interpretations of probability expressions, however. Investigating context dependence, Wallsten, Fillenbaum, and Cox (1986) found people's numerical evaluations of probability words dependent on the base rate of the outcome that the word was qualifying. Thus people interpreted the word "likely" as conveying a higher numerical probability when it described the probability of rain in London as opposed to rain in Cairo. The numerical equivalent of the perceived probability of an event was a weighted average of the probability implied by the word "likely" per se and the base rate probability of the event (rain in London vs. rain in Cairo).

The base rate of occurrence may not be the only characteristic of an outcome that influences people's perceptions of its probability of occurrence. Weber and Hilton (1990) hypothesized and found that the disutility or negative valence of an outcome also affects people's interpretations of the probability with which the outcome was predicted to occur. Thus, "slight chance" was interpreted differently when referring to a slight chance of gastric disturbances as opposed to a slight chance of skin cancer, not just because these two outcomes have different a priori base rates, but also because skin cancer is a more severe outcome (with greater negative valence) than gastric disturbances. People's numerical interpretations of probability words depended on the base rate as well as on the severity of the outcome predicted to occur, with more severe outcomes leading to reports of higher numerical probability equivalents for a given probability phrase after controlling for the effects of base rates. Thus most people gave "slight chance of gastric disturbances" a higher numerical interpretation than "slight chance of skin cancer" because of the greater base rate of gastric disturbances which masked the opposite effect due to the severity difference. However, for individuals who considered their personal base rates of experiencing gastric disturbances and skin cancer to be the same, "slight chance of skin cancer" got a higher probability interpretation than "slight chance of gastric disturbances" because of its greater severity. Cohen and Wallsten (1991) found that greater positive valence of outcomes also increased people's interpretations of associated probability words.

The psychological mechanism that is sufficient to account for all of these phenomena is sensitivity to the consequences of misestimating an uncertain quantity. Consequences are often asymmetric for over- vs. underestimates (i.e., loss functions are asymmetric) and can either be externally imposed (e.g., a reprimand for underestimates of the costs of a new venture, but indifference for overestimates) or internally imposed (e.g., great disappointment about an outcome smaller than expected, but only small elation about an outcome greater than expected; Bell, 1985). When loss functions are symmetric, expected utility maximization will also minimize expected post-decision losses. When loss functions are asymmetric, special cases of rank-dependent utility maximization can be shown to minimize expected post-decision losses. Asymmetric loss function minimization provides an explanation for observed subjective probability distortions described by venture theory (Hogarth & Einhorn, 1990), value distortions described by social judgment theory (Taylor, 1991), and buying vs. selling price difference that are too large to be explained by other economic arguments (Birnbaum et al,. 1992).

On-going research in this area compares the asymmetric loss function explanation with competing explanations for rank-dependent utility evaluation. I am currently conducting an experiment designed to determine the relative contributions of strategic factors (e.g., conscious or unconscious minimization of asymmetric loss functions), perceptual factors (e.g., greater weight being given to outcomes at both ends of the distributions because they are more noticeable; Tversky & Kahneman, 1992), and processing simplifications in the form of editing operations (Wu, 1994). Knowing why and how utility evaluation departs from a prescriptive model is important. If rank-dependent utility evaluation has perceptual sources (analogous to visual illusions), modification may be difficult and would involve focusing people's attention more evenly on all possible decision outcomes. If asymmetric loss functions drive deviations from expected-utility maximization, decision makers should be able to determine the source and desirability of the imposed loss function. If asymmetric consequences are externally imposed, a change in the environment (e.g., incentive system) will be required to change people's behaviour that, quite rationally, reflects outside constraint. If asymmetric consequences are internally imposed (i.e., "psychological"), the decision maker needs to be made aware of these self-imposed constraints and decide whether s/he wants them to be in place. There also are agency issues. If a decision has consequences for parties other than the decision maker (e.g., for a company or a constituency), then psychological benefits such as disappointment minimization for the decision maker may come at the price of a loss in financial benefits for other stakeholders.

Risk-Value Models of Choice and Models of Risk Perception

Another contribution of psychology to decision theory is its demonstration that behaviour is not directly determined by physical stimuli and events, but by people's perception of them. Recent work on risk perception fits into this tradition. The benefit of considering subjective experience (as an intervening variable) is that it makes behaviour more predictable, as, for example, the assumption that choices are not directly determined by the (objective) outcomes of choice alternatives but by people's (subjective) utility for them. Allowing for subjective experience also opens the door to a consideration of individual differences. Most would agree that utility as well as subjective probability functions are useful constructs, and that it is convenient and parsimonious to describe individual differences in choice by differences in people's utility for outcomes and perceptions of likelihood. Recent research has shown that risk perception as a psychological variable can also differ between individuals and as a function of context and prior outcome history. The work also connects risk perception to choices and has helped to reconcile the puzzling result that people appear to be risk seeking in the domain of losses with the traditional economic assumption that people are universally risk averse.

In a study of commuter reactions to trains with risky arrival times and in a stock-market investment simulation, Weber and Milliman (1994) showed that the same factors that affect risky choices (e.g., whether the outcomes are gains or losses; the prior outcome history) also influence the perception of the relative riskiness of different choice alternatives. If risk attitude is defined as the tendency to choose options perceived to be more risky (i.e., risk-seeking) or less risky (i.e., risk-averse), then risk attitudes stayed the same (mostly risk-averse) in the loss and the gain domain for the majority of respondents, even though preference often changed, replicating Kahneman and Tversky's (1979) reflection effect. Behaviour that is variance-seeking in the loss domain may not be "risk-seeking" in the sense that people choose what they perceive as the riskier alternative. Instead, they may define riskiness as something other than variance. Weber, Anderson, and Birnbaum (1992) showed that risk judgments of financial gambles are neither judgments of outcome variance, nor simply judgments of "unattractiveness." The distinction between differences in the perception of risk and differences in attitude towards risk as the determinant of differences in choice has implications for decision aiding and training. If potentially undesirable risky decisions are driven by idiosyncratic risk perception, then remedial steps should involve informational or cognitive interventions, aimed at giving decision makers a more realistic perception of the risks. If risk attitudes are at fault, then intervention needs to target people's emotional responses towards uncertainty.

Risk-return models are central to the theory of asset allocation in finance. The most widely used model assumes "returns" to be the expected return of an asset and "risk" to be the variance of the asset return's distribution (Markowitz, 1959, and CAPM extensions). With growing realization that variance may be descriptively inappropriate as a measure of risk, other capital asset pricing models have been proposed. As discussed by Sarin and M. Weber (1993), in market equilibrium only part of the prescriptive risk of an asset is priced with such alternative models.

One descriptive axiomatic model of perceived risk that has been developed and tested over a number of years (Weber, 1984, 1988b; Luce & Weber, 1986; Weber & Bottom, 1989, 1990) is the conjoint expected risk (CER) model. The CER model captures both similarities in people's risk judgments (by assuming that the functional form by which probability and outcome information is combined is the same across individuals) and individual differences (with the help of model parameters that reflect the relative weight given to positive and negative outcome and probability information). Thus the perceived riskiness, R, of risky prospect X is described as:

$$\begin{aligned} R(X) = {} & A_0 Pr(X=0) + A_+ Pr(X>0) + A_- Pr(X<0) \\ & + B_+ E[X^{k+} \mid X>0] Pr(X>0) + B_- E[X^{k-} \mid X<0] Pr(X<0), \end{aligned}$$

i.e., is a linear, weighted combination of the probability of breaking even, the probability of winning, the probability of losing, the conditional expectations of positive outcomes raised to the power k^+, and the conditional expectation of negative outcomes raised to the power k^-, where $k^+, k^- > 0$.

Other descriptive models of risk also exist (e.g., M. Weber, 1990; see Weber, 1988, and Sarin & M. Weber, 1993, for reviews). However, Yates and Stone (1992) have called the CER model the "most viable model" to describe "single-dimension risk appraisal" (e.g., risk appraisal of financial gambles). Holtgrave and Weber (1993) tried to connect the previously disparate literature on risk perception for financial decisions with the literature on perceptions of health and safety risks. They compared the fit of a simplified version of the CER-model, originally developed for financial gambles, with the fit of the psychometric risk dimensions model by Slovic, Fischhoff, and Lichtenstein (e.g., 1986), originally developed for health and safety risks. A hybrid model that added one of Slovic et al.'s seven psychological risk dimensions (namely "dread") to the CER model turned out to do the best job in describing the risk perceptions of University of Chicago MBAs for both financial and health and safety decisions. The study shows that risk perception in different content domains can be captured by the same model. It also shows that risk perception for financial stimuli has an "emotional" component that is not completely described by the components of the CER model (i.e., by the probability of loss, gain, or status quo; and the expected loss or gain). This result may well have implications for the identification of noise traders, i.e., traders who base their investment decisions partly on irrational factors (Lee, Shleifer, & Thaler, 1991).

3) Decision goal alternatives to utility maximization

Both traditional expected utility theory and the non-expected utility models discussed above make the implicit assumptions that people's goal in choice is the maximization of subjective utility, however utility might be determined or defined. This assumption has also legitimized the widespread use of simple monetary gambles to test decision models. If people's decision goal is to maximize some form of expected utility, which is some function of the probabilities and values of possible outcomes, then abstract, content-free money lotteries reflect choice alternatives in their purest form, and gambles become a metaphor for all of life's decisions.

In recent years, however, this generality and appropriateness of the gambling metaphor has been questioned. Goldstein and Weber (1994) provide a review of the reasons for current revisions and extensions of abstract, utility-maximizing, content-independent choice theories. The remainder of this paper will describe two alternative goals, and thus methods or rules, that people may use to make a decision.

Reason-Based Choice

Shafir, Simonson, and Tversky (1993) reviewed a number of studies that showed violations of traditional models of utility maximization and interpreted these violations in terms of the reasons (in particular, the number of reasons) that a person might offer in support of a decision. A richly described alternative with both good and bad aspects, for example, provides many reasons why it should be chosen over a more neutral or sparsely described alternative. However, it also provides many reasons for why it should be rejected. Shafir (1993) found that people instructed to choose, chose the rich alternative, and that people instructed to reject, rejected it. The assumption that people "count" the number of reasons they have for their decision (be it to choose or to reject) explains this result. In another example, the fact that an alternative (B) dominates alternative A, while another alternative (C) does not, provides a reason for selecting B over C (Tversky & Shafir, 1992). Montgomery's (1983) theory and evidence of people trying to restructure decision alternatives in ways that bring out dominance relationships is also consistent with the notion that the goal of some decisions may not only or even primarily be utility maximization but instead justifiability.

Explanation-Based or Story-Based Choice

Explanation-based decision-making, proposed by Pennington and Hastie (1988) and investigated extensively as applied to juror decisions in criminal trials, consists of three parts: (1) the decision maker constructs a causal model to explain available facts (e.g., a narrative story is constructed from witness testimony and attorney arguments to explain the actions of the defendant and others in the case); (2) the decision maker endeavors to learn, create, or discover choice alternatives (e.g., the judge instructs the jury about the possible verdicts and the conditions for their appropriateness); and (3) the decision is made when the causal model is successfully matched to an available choice alternative.

The key property of explanation-based decision making is that it depends crucially on the construction of the mediating representation, i.e., the causal model. The causal model organizes much (ideally all) of the information into a whole, by promoting and guiding the inference of information that was not presented explicitly (e.g., that the defendant formed a goal to harm the victim) and relations between items (e.g., various actions of the defendant are interpreted as efforts to achieve his or her goal). Pennington and Hastie (1992, 1993) showed that people's decisions and the confidence they placed in those decisions could be predicted from their evaluations of the consistency and completeness of different causal models. Thus people chose the decision alternative that created the most coherent "story" out of all the available information.

Goldstein and Weber (1994) argue that the goal and thus method of decision making may depend on the content or context of the decision. Utility maximization is probably the most natural and common decision rule in financial decisions or choices between different models of most consumer products. If the decision maker anticipates, however, that he or she may be asked to justify the choice, it makes sense to choose the alternative that is most justifiable. Finally, for decisions between alternatives

whose consequences will unfold over time (e.g., decisions between potential marriage partners or between alternative job offers), people may use a decision rule that turns each alternative into a "narrative" about a possible future life and selects the most coherent and appealing narrative.

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