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An Introduction to Prospect Theory

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Prospect theory has emerged as a leading alternative to expected utility as a theory of decision under risk and has very recently begun to attract attention in the literature on international relations. The theory is best known for its hypothesis that individuals are risk-averse with respect to gains and risk-acceptant with respect to losses and for its emphasis on the importance of the actor's framing of decisions around a reference point. I begin this essay with a brief summary of expected utility theory and of some of the apparent empirical anomalies in the theory. I then show how prospect theory integrates these descriptive patterns into an alternative theory of risky choice. I discuss both the framing of decisions and the evaluation of prospects in terms of a value function and a probability weighting function.

KEY WORDS: expected-utility theory; prospect theory; risk propensity; framing; loss aversion; endowment effect; certainty effect.

INTRODUCTION

Since its formulation by Kahneman and Tversky in 1979, prospect theory has emerged as a leading alternative to expected utility as a theory of decision under risk. Prospect theory posits that individuals evaluate outcomes with respect to deviations from a reference point rather than with respect to net asset levels, that their identification of this reference point is a critical variable, that they give more weight to losses than to comparable gains, and that they are generally risk-averse with respect to gains and risk-acceptant with respect to losses. The hypothesized pattern of loss aversion and the importance of framing have received tentative confirmation by a series of diverse and robust experimental tests that are now well-known in the literature on behavioral decision theory (Kahneman &

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Tversky, 1979; Tversky & Kahneman, 1986; Fishburn & Kochenberger, 1979; Schoemaker, 1980).

Over the last several years a handful of international relations scholars, most prominently Robert Jervis (1988, 1989, 1991), have begun to apply the concepts of framing, loss aversion, and varying risk propensities to foreign policy decision-making. These concepts have been used primarily in a supplemental role to modify other theoretical propositions in most applications of the theory (Jervis, 1988, pp. 696–698, 1989, pp. 94–95, 168–172; Lebow, 1987, p. 54; Levy, 1987, pp. 101–103; 1989a, p. 274; 1989b, pp. 126–127; Maoz, 1990; Huth, Gelpi, & Bennett, 1992). Recently, however, key components of prospect theory have been given a more central role in international relations theorizing (Stein, 1992; Jervis, 1992) and have been used as central organizing concepts to structure case studies of foreign policy decision-making (Farnham, 1992; McInerney, 1992; McDermott, 1992).

Although interest in prospect theory has been growing among international relations theorists, its details remain unfamiliar to the vast majority of scholars in the field. Consequently, this is a good time to review the essential elements of the theory and to evaluate the analytical problems that might affect its utility as a framework for research in international relations and foreign policy. Because prospect theory was developed in response to expected utility theory, I begin this introductory essay with a very brief review of expected utility, note some frequently observed empirical violations of that theory, and show how prospect theory integrates these observed patterns into an alternative theory of risky choice.

I will not deal here with debates in the social psychology, economics, and decision-theory literature regarding the empirical validity of prospect theory and experimental tests of the theory in the laboratory (Hershey & Shoemaker, 1980b; Machina, 1982; Slovic & Lichtenstein, 1983). Nor will I be concerned with the broader questions of whether observed violations of expected utility constitute "irrational' behavior or invalidate the theory, whether prospect theory is superior to expected utility theory, or whether normative and descriptive theories of decision are ultimately reconcilable (Tversky & Kahneman, 1986). I will analyze the potential contribution of prospect theory for international relations later in this issue (Levy, 1992).

EXPECTED-UTILITY THEORY—A BRIEF REVIEW

Expected utility is a theory of decision under conditions of risk, where each option leads to one of a set of possible outcomes and where the probability of each outcome is known. (Risk differs from uncertainty, where the probabilities of

outcomes are not completely known, and from certainty, where the probabilities are known and equivalent to zero or one.) The expected-utility principle asserts that individuals attempt to maximize expected utility in their choices between risky options: they weight the utilities of individual outcomes by their probabilities and choose the option with the highest weighted sum (Luce & Raiffa, 1957, Ch. 2).

Since Bernoulli's (1954) proposal of the expected-utility principle in 1738, it has usually been assumed that the psychological value of money and most other goods does not increase proportionally with objective amount, but instead that there is diminishing marginal utility for money. This can be represented by a concave (downward curving) utility function. Individuals can also have increasing or constant marginal utility for a particular good, which can represented by a convex or linear utility function, respectively.

An actor's attitude toward risk is conventionally defined in terms of marginal utility or the shape of the utility function. An actor is risk-averse if the utility function is concave, risk-neutral if the utility function is linear, and risk-acceptant if the utility function is convex. Given a choice between two options, one involving a certain outcome of utility x and the other involving a lottery or gamble with the equivalent expected utility x, a risk-averse actor will prefer the certain outcome to the gamble, a risk-acceptant actor will prefer the gamble, and a risk-neutral actor will be indifferent between the two. Most people are risk averse with respect to monetary outcomes and prefer a certain payoff of \$50 (or even \$40) to a 50/50 chance of either nothing or \$100.

Expected-utility theory has dominated the analysis of decision-making under risk, both as a normative model of rational choice and a descriptive model of how people actually behave. But not all of its predictions appear to be fully consistent with observed behavior.[2] These empirical anomalies in expected-util-

[2]For example, gambling and insurance behavior present a dilemma for expected-utility theory. The assumption of diminishing marginal utility for money implies that people should shy away from lotteries and other gambles to win large amounts of money at small probabilities, but this is inconsistent with the popularity of gambling. Expected-utility theory can account for gambling by assuming convex utility functions, but that would leave it at odds with a wide range of behavior for which individuals appear to be risk averse. This includes the proclivity to purchase insurance, which involves a certain small loss in order to avoid a small probability of a very large loss (Friedman & Savage, 1948). Expected-utility theory can easily explain gambling *or* insurance, but it cannot easily account for both gambling and insurance by a single individual. The dilemma can be eliminated if utility theory were to posit that individuals have different utility functions for different domains of behavior. But this would add significantly to the complexity of the explanation, involve a significant loss in parsimony, and possibly introduce a tautological element into a theory of behavior.

In fact, insurance behavior is rather complex. People commonly purchase insurance but often hesitate to insure against extremely improbable outcomes. They also tend to shun "probabilistic insurance" (Kahneman & Tversky, 1979, pp. 269–271), which should be attractive for individuals with diminishing marginal returns for money, and they deviate in other ways from predicted behavior regarding insurance (Slovic et al., 1977; Schoemaker, 1980, Ch. 5; Slovic, Fischoff, & Lichtenstein, 1988, pp. 156–158).

ity theory led Kahneman and Tversky (1979) to develop prospect theory as an alternative theory of decision under risk.

THE DESCRIPTIVE FOUNDATIONS OF PROSPECT THEORY

Kahneman and Tversky (1979) begin by presenting the results of a series of laboratory experiments involving hypothetical choices, and it would be useful to summarize some of the most important findings here. Most of their examples refer to risky choice regarding monetary outcomes, but many of their findings can be generalized to other forms of risky choice.

(1) People tend to think in terms of gains and losses rather than in terms of their net assets, and therefore encode choices in terms of deviations from a *reference point.* Kahneman and Tversky (1979, p. 273) argue that "the carriers of value or utility are changes of wealth, rather than final asset positions that include current wealth." They acknowledge that asset position matters in principle, but argue that "the preference order of prospects is not greatly altered by small or even moderate variations in asset position" (p. 277). The reference point is usually the status quo, but that need not necessarily be the case. One can also speak of deviations from an *aspiration level* or some other reference point which is not equivalent to the status quo. This possibility leads to some interesting questions regarding the framing of a choice problem, to which we will return.

(2) People treat gains differently than losses in two respects. First, individuals tend to be risk-averse with respect to gains and risk-acceptant with respect to losses. In a typical experiment (Kahneman & Tversky, 1979), 80% of respondents preferred a certain outcome of $3000 to an 80% chance of $4000 and 20% chance of nothing. If faced with the same two negative prospects, however, 92% of respondents preferred to gamble on an 80% chance of losing $4000 and 20% of losing nothing to a certain loss of $3000. In both cases respondents chose the option with the lower expected value and the combination of these two patterns is inconsistent with expected-utility theory. There is no conclusive evidence on exactly *how* risk-averse or risk-acceptant people are (or how much they are willing to sacrifice in expected value in order to avoid a certain loss or secure a certain gain), but figures in the 20%–30% range are not uncommon in laboratory experiments.

These experiments suggest that individual utility functions are concave in the domain of gains and convex in the domain of losses, a pattern which Kahneman and Tversky (1979, p. 268) refer to as a *reflection effect* around the reference point. This means, among other things, that the sensitivity to changes in assets decreases as one moves further from the reference point in both directions, which would not be true of a utility function which was either strictly concave or strictly convex. This pattern has been found repeatedly for a variety of individuals and

situations (Fishburn & Kochenberger, 1979), but it may break down for very small probabilities or for catastrophic losses, which we will consider later.

(3) Gains are also treated differently than losses in that "losses loom larger than gains." As Jimmy Conners exclaimed, "I hate to lose more than I like to win." This phenomenon of *loss aversion* implies that people prefer the status quo (or another reference point) over a 50/50 chance for positive and negative alternatives with the same absolute value. It also implies that people value what they have more than "comparable" things they do not have. The very process of acquiring an object enhances the value of that object, even for items as trivial as candy bars or coffee mugs. This over-evaluation of current possessions has been called the *endowment effect* (Thaler, 1980, pp. 43–47).

Loss aversion and the endowment effect imply that selling prices should be higher than buying prices: the minimal compensation people demand to give up a good is often several times larger than the maximum amount they are willing to pay for a commensurate entitlement. The endowment effect and evaluation disparities have been repeatedly demonstrated in the experimental literature (Knetsch & Sinden, 1984; Knetsch, 1989; Kahneman, Knetsch, & Thaler, 1990).[3] They largely account for the tendency for people to overweight out-of-pocket costs (losses) relative to opportunity costs (foregone gains), and there is evidence that they affect peoples' judgments of fairness and justice (Kahneman, Knetsch, & Thaler, 1991, pp. 203–204). The endowment effect and evaluation discrepancies are also reflected in legal doctrine, which recognizes an asymmetry between acts of commission and omission, and which distinguishes between "loss by way of expenditure and failure to make a gain." People are more likely to be entitled to compensation for actual losses than for denied opportunities to secure gains (Kahneman, Knetsch, & Thaler, 1990, p. 1246, 1991, pp. 202–204).

The endowment effect also has important implications for utility theory. It challenges the assumptions that preferences are invariant under different representations of equivalent choice problems (because framing affects preferences), that indifference curves are reversible and nonintersecting, and that preferences are independent of endowments (one's preference between A and B may depend on whether A is currently part of one's endowment) (Knetsch, 1989;

[3]The gap between compensation demanded and willingness to pay may be up to 3 or 4 to 1 (Kahneman, Knetsch, & Thaler, 1990, p. 1336; Hartman, Doane, & Woo, 1991, p. 142). Some studies have proposed and tested alternative explanations for these "evaluation disparities" between buyers and sellers. Knez, Smith, and Williams (1985) suggest that the observed gap is a manifestation of routine application of normally sensible bargaining habits to laboratory experiments (for sellers to inflate and buyers to deflate prices for strategic reasons), and Coursey, Hovis, and Schulze (1987) report that these discrepancies diminish with learning in repeated trials. But Kahneman, Knetsch, and Thaler (1990) and Knetsch and Sinden (1987) control for these possible effects and find that these evaluation disparities do not disappear under a wide range of conditions.

Slovic & Lichtenstein, 1983; Tversky, Slovic, & Kahneman, 1990; Kahneman et al., 1990).

The endowment effect exists even if the endowment is a windfall and therefore somewhat artificial, though the effect may be slightly weaker under such conditions. For this reason, we might expect laboratory studies to underestimate the true magnitude of endowment effects (Knetsch, 1989, p. 1282). Moreover, the longer one possesses a good, and particularly the greater the effort and resources expended to acquire it, the greater its perceived value, as cognitive dissonance theory would suggest (Jervis, 1989, p. 169). The symbolic value of political and economic assets in international relations should further strengthen the endowment effect.

It should be noted, however, that the endowment effect and loss aversion do not appear to apply to normal commercial transactions. Money expended on an item is not treated as a loss, and goods purchased for eventual sale or barter—as opposed to use—generally do not generate an endowment effect (Kahneman et al., 1991, p. 200). In addition, the experimental evidence, though tentative, suggests that endowment effects are stronger and more consistent if one is given physical possession of a good, as opposed to a property right to receive the good at some point in the future or a chance (as opposed to certainty) to receive such a good (Kahneman et al., 1990, p. 1342).

(4) Because of the encoding of outcomes in terms of a reference point and the differential treatment of gains and losses, the identification of the reference point, or *framing* of a choice problem, becomes critical. One striking demonstration of the significance of the framing effect is illustrated by the following medical example (Tversky & Kahneman, 1981, p. 453). Subjects were given a hypothetical choice between alternative programs to combat the outbreak of a disease which was expected to kill 600 people. The identical statistics (asserted to be a consensus of scientific opinion) regarding the expected consequences of the epidemic and the two treatment programs were presented to one group in terms of the number of people who would be saved (the "survival frame"), and to another group in terms of the number of people who would die from the disease (the mortality frame). Specifically, in program A, 200 people would be saved (or 400 would die), and in program B there was a one-third chance that 600 people would be saved (none would die) and two-thirds probability that none would be saved (600 would die). A strong majority (72%) favored the cautious alternative A in the survival frame, but a comparable majority (78%) favored the risky alternative in the mortality frame.[4]

[4]There is a potential levels-of analysis problem or ecological fallacy which needs to be explored in problems of this kind. Experimental tests on risk propensities in the domains of losses and in the domain of gains are conducted on two distinct sets of subjects so that aggregate results do not necessarily imply a reflectivity effect in *individuals*. Experiments which adopt an individual-level

In effect, the survival frame involves a downward shift in the reference point, which is equivalent to adding a positive constant to all outcomes. This downward *translation effect* (Abelson & Levi, 1985, p. 248) influences outcomes by increasing the tendency toward risk aversion. Thus whether a respondent frames the issue in terms of gains or losses has a significant impact on preferences in spite of the mathematical equivalence of the two choice problems. The importance of framing has been demonstrated by a number of other experimental studies (McNeil, et al., 1982; Levin et al., 1985; Tversky & Kahneman, 1986; Fleishman, 1988). The preference of gas stations and other businesses for offering customers a cash discount rather than requiring a credit card surcharge, in order to frame the issue as a gain rather than a loss for the consumer, reflects an anticipation of framing effects.

Although in many simple choice problems the framing of the problem is largely predetermined by the situation (or the experimental design), in other situations it is more subjective and sensitive to how the individual responds to a situation and encodes a decision. This is particularly likely where the situation involves a sequence of successive choices and where there is ambiguity regarding the status quo. Is the reference point for each choice problem framed cumulatively with respect to one's asset position at the beginning of the series of choices, or with respect to one's asset position at each individual choice? A gambler who sustains a series of losses will be more inclined to be risk acceptant if he or she adopts the cumulative frame of the asset position at the beginning of the evening and attempts to recover losses, whereas one who uses current asset levels would be more risk averse. Someone on a winning streak, however, will be more risk averse if he or she frames the choice in terms of initial assets rather than total assets at the time of each new bet.

This example illustrates the importance of how individuals *accommodate* to gains or losses. Accommodation to losses induces a tendency toward risk aversion (relative to nonaccommodation), whereas accommodation to gains induces risk-seeking behavior to keep those gains (Abelson & Levi, 1985, p. 249). This leads to the question of how quickly individuals or states adjust or *renormalize* (Jervis, 1992) to a new status quo, and under what conditions or types of situations. The literature speaks of an instant endowment effect (Kahneman et al., 1990, p. 1342) and implies that actors accommodate to gains more quickly than to losses. This has significant consequences for strategic interaction in dynamic situations. If A has just made a gain at the expense of B, B's attempt to recover his losses (from the old status quo) will be perceived as a potential loss by A (from the new status quo), so that both parties will be in a domain of losses

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(as opposed to aggregate) focus (Hershey & Schoemaker, 1980b) show weaker tendencies toward reflectivity.

and be more risk-seeking. We will return to applications of this hypothesis to bargaining situations in international relations.

(5) A number of studies have shown that individuals overweight outcomes which are certain relative to outcomes which are merely probable—the *certainty effect* (Allais, 1979; Kahneman & Tversky, 1979). They also overweight small probabilities and underweight moderate and high probabilities, and the latter effect is more pronounced than the former. Extremely likely but uncertain outcomes are often treated as if they were certain, which Kahneman and Tversky (1986, p. S268) call the *pseudocertainty effect*. Consequently, changes in probabilities near 0 or 1 have a greater impact on preferences than comparable changes in the middle of the probability range, which leads to the *ratio-difference principle* or *subproportionality:* the impact of any fixed positive difference between two amounts increases with their ratio (Quattrone & Tversky, 1988, p. 728; Tversky & Kahneman, 1986, p. S263).

The differential evaluation of the complete elimination as opposed to the reduction of risk is illustrated by the fact that people are willing to pay far more to reduce the risk of a catastrophic loss from .10 to 0 than from .20 to .10, even though the change in expected utility is the same. More graphically, people in a hypothetical game of Russian roulette are willing to pay far more to reduce the number of bullets in a revolver from 1 to 0 than from 4 to 3 (Quattrone and Tversky, 1988, p. 730). These forms of behavior are contrary to the expectation rule (that the utilities of risky outcomes are weighted linearly by their probabilities) and ratio-scale properties of expected-utility theory.

The effects of the overweighting of small probabilities may be reinforced by the availability heuristic (Tversky & Kahneman, 1982), in which dramatic events which come readily to mind (television images of disaster, for example) are perceived to be more likely than they actually are. Note, however, that the *overestimation* or exaggeration of probabilities, which may arise from the availability heuristic or from other cognitive or motivational biases (Jervis, 1976; Janis & Mann, 1977), is analytically distinct from the *overweighting* of low probabilities. Overestimation refers to the subjective assessment of probabilities, and may be influenced by the vividness of an event category or by other cognitive or motivational biases. Overweighting is a property of the weighting function, which operates on subjective probabilities assessments independently of the processes by which they are generated, as demonstrated by laboratory experiments in which probabilities are given (Kahneman & Tversky, 1979, p. 281).

(6) There is also evidence that in order to simplify the choice between alternatives, individuals often disregard components that are common to each alternative option, and focus on components which are different (Tversky, 1972). This *isolation effect* (or *cancellation*) can lead to different preferences because there may be more than one way to decompose prospects into shared and dis-

tinctive elements, as Kahneman and Tversky (1979, p. 271) demonstrate in experiments involving two-stage choice problems.[5]

The aforementioned patterns of behavior with respect to judgment and decision violate several of the basic assumptions of expected-utility theory in nontransparent choice situations (as opposed to more transparent choice situations in which the similarities between problems is more obvious), including transitivity, dominance, invariance, and cancellation (or the independence of irrelevant alternatives).[6] In an attempt to incorporate these behavioral patterns, scholars have formulated a number of alternative models of risky choice (for a brief review and evaluation see Tversky & Kahneman, 1986, pp. S271–S273; Abelson & Levi, 1985, pp. 250–254). Prospect theory is the most comprehensive and best known of these.

PROSPECT THEORY: A SUMMARY

Prospect theory attempts to incorporate the observed violations of expected utility into an alternative theory of risky choice. It distinguishes two phases in the choice process: (1) The *editing phase* involves a preliminary analysis of the choice problem. It includes the identification of the options available to the actor, the possible outcomes or consequences of each, and the values and probabilities associated with each of these outcomes. It also includes the organization and reformulation of perceived options so as to "simplify subsequent evaluation and

[5]Consider the following two-stage problem from Kahneman and Tversky (1979, pp. 271–272). In the first stage there is a .75 probability of ending the game with zero payoff and .25 probability of moving to the second stage. In this second stage, there is choice between a certain payoff of $3,000 and an .80 probability of $4,000. The choice between these two prospects must be made before the outcome of the first stage is known. In this "sequential" frame, 78% of 141 subjects chose the second prospect. Note that this choice problem is equivalent to a one-time choice between a .20 probability of a payoff of 4,000 and a .25 probability of 3,000. In this "standard" frame, 65% of 95 respondents selected the first prospect. Kahneman and Tversky (1979) hypothesize that subjects ignored the first stage of the game in the sequential game because it was common to both prospects. This results in a fourfold increase in the probabilities to be evaluated, the introduction of a certain prospect, a corresponding change in probability weightings, and a preference reversal and violation of the invariance axiom (see fn. 6).

[6]*Transitivity* requires that if A is preferred to B and B to C, then A is preferred to C. *Dominance* means that if one option is better than another in one state of the world and at least as good in all other states, the dominant option should be chosen. *Cancellation*—which is equivalent to the substitution axiom (von Neumann and Morgenstern, 1944), the extended surething principle (Savage, 1954), and the independence of irrelevant alternatives—refers to the elimination of any state of the world that yields the same outcome regardless of one's choice. *Invariance*, or "extensionality" (Arrow, 1982), requires that different representations of the same (i.e., mathematically equivalent) choice problem should yield the same preferences (Tversky & Kahneman, 1986, pp. S253–S254). On the axiomatic foundations of utility theory, see Luce and Raiffa (1957, Ch. 2). For a discussion of behavioral violations of these axioms, see Kahneman and Tversky (1979), Arrow (1982), Tversky and Kahneman (1986, pp. S252–S254), and Tversky, Slovic, and Kahneman (1990).

choice" (Tversky & Kahneman, 1981, p. 453; Kahneman & Tversky, 1979, p. 274). (2) In the *evaluation* phase, the edited prospects are evaluated and the preferred prospect is selected. Kahneman and Tversky have developed a formal model to explain the evaluation of prospects, but the theory of editing or framing is less well-developed. Both the editing and evaluation phases are essential to prospect theory, although the former has received less attention.

Editing involves several mental operations which simplify the choice problem by transforming the representation of outcomes and probabilities. *Coding* involves the identification of a reference point and the *framing* of outcomes as deviations (losses or gains) from that reference point, and this can affect orientation toward risk. *Simplification* involves rounding off probabilities or outcomes, including discarding extremely unlikely outcomes by rounding their probability to zero, and can distort expected utility calculations. *Detection of dominance* entails the search for and elimination of dominated alternatives. There is also a *combination* of probabilities associated with identical outcomes and a *segregation* of a riskless component of a prospect from a risky component which is then evaluated with respect to its deviation from the assured minimum. There is often the *cancellation* of components common to all prospects or the elimination of irrelevant alternatives, which can lead to preference reversals and violations of invariance. These editing operations are discussed in more detail by Kahneman and Tversky (1979, pp. 284–285).

Editing is an integral component of the choice process and is essential if prospect theory is to be able to explain violations of invariance, preference reversal, intransitivities, and other anomalies of preference described above (Abelson & Levi, 1985, p. 250). In complex choice situations, however, exactly how choice problems are edited is difficult to predict because the process is influenced by the "norms, habits, and expectancies of the decision maker" as well as the features inherent in a choice problem (Tversky & Kahneman, 1986, p. S257). Moreover, the outcome of the editing process may be a function of the sequence of editing operations. Whether simplification takes place before or after combination and/or segregation, for example, may make a difference in the final editing of choices and introduces an additional element of unpredictability in decision-making.

For these reasons, Kahneman and Tversky (1979, p. 275) restrict themselves to choice problems "where it is reasonable to assume either that the original formulation of the prospects leaves no room for further editing, or that the edited prospects can be specified without ambiguity." That is, Kahneman and Tversky focus on the evaluation of prospects rather than the editing of choices, and the behavior they observe is determined primarily by the evaluation phase of decision-making. Needless to say, editing plays a much greater role in choice situations in international relations and requires far more theoretical and empirical attention.

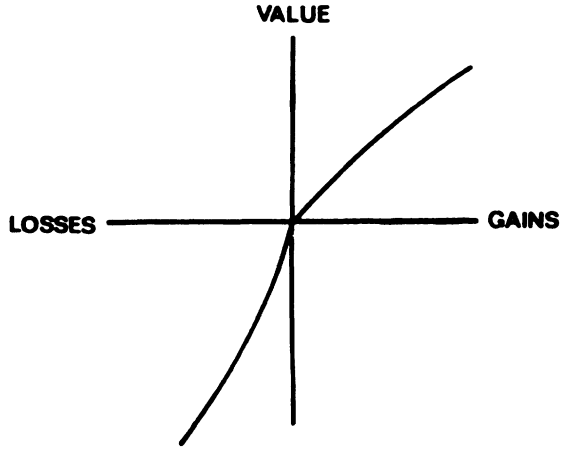

Fig. 1. A hypothetical value function.

Once the individual edits the available options, she then evaluates the edited prospects and selects the one with the highest value, as determined by the product of a value of an outcome and a decision weight. The weighted value of a prospect V is given by

$$V = \Sigma w\ (p_i) * v(x_i),$$

where p is the perceived probability of outcome x, $w(p)$ is the probability-weighting function, and $v(x)$ is the value function.

The *value function* has three main characteristics, which reflect the behavioral patterns summarized above: (1) It is defined on deviations from a reference point, rather than on net asset position (thus if the reference point shifts, the value function shifts accordingly); (2) it is generally concave for gains and convex for losses, reflecting risk aversion in the domain of gains and risk seeking in the domain of losses; (3) it is steeper for losses than for gains (perhaps by a ratio of 2:1, according to the experimental evidence [Tversky & Kahneman, 1991]). This captures the phenomenon of loss aversion and implies that the marginal utility of gains decreases faster than the marginal disutility of losses. A typical S-shaped value function is presented in figure 1.

The *probability-weighting function* measures the impact of the probability of an event on the desirability of a prospect. It is not a linear function of probability, however, and decision weights are not themselves probabilities. Technically, decision weights could be influenced by factors other than probability, including "ambiguity," or uncertainty about the level of uncertainty or risk (Kahneman & Tversky, 1979, p. 280; Ellsberg, 1961; Einhorn & Hogarth, 1985).

A typical probability-weighting function, induced from experimental evi-

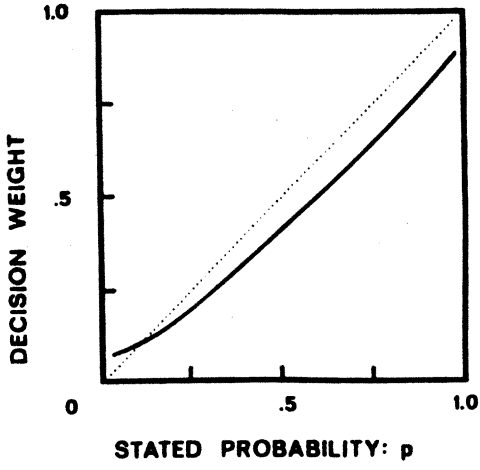

Fig. 2. A hypothetical weighting function.

dence, is given in figure 2. It has several characteristics. First, the weighting function is not well-behaved near its endpoints. This reflects the unpredictability of behavior under conditions of extremely small or extremely large probabilities. In other words, the variance in the probability weighting function is not constant and is quite large in the region near 0 or 1. Kahneman and Tversky (1979, pp. 282–283) acknowledge this unpredictability, and argue that "because people are limited in their ability to comprehend and evaluate extreme probabilities, highly unlikely events are either ignored or overweighted, and the difference between high probability and certainty is either neglected or exaggerated."

The fact that the weighting function is not well-behaved near its endpoints, and that by definition $w(0) = 0$ and $w(1) = 1$, leads to a second important characteristic: there is a sharp (though somewhat indeterminant) increase in the weighting function in these regions. Thus changes in probabilities near 0 or 1 have disproportionately large effects on the evaluation of prospects.

A third characteristic of the weighting function is that its slope is less than 1 across its entire range, except for the small region near its endpoints. Because the slope is a measure of the sensitivity of decision weights— and therefore of preferences—to changes in probabilities, this means that preferences are generally less sensitive to variations in probability than the expectation principle would suggest (with the important exception of the region near 0 and 1). One implication is that the sum of decision weights associated with complementary events is generally less than the weight given to a certain event, which reflects the certainty effect described above (Kahneman & Tversky, 1979, p. 282).

Fourth, other than the indeterminacy of behavior for extremely small proba-

bilities, small probabilities are overweighted while larger probabilities are underweighted. Although there is no conclusive evidence as to the specific point at which overweighting shifts to underweighting, or whether this point varies significantly across individuals or conditions, it appears from typical experiments that this point falls in the .10–.15 range (Hershey and Shoemaker [1980] use .12). Thus it is clear that probabilities are underweighted over most of their range. This leads to a fifth characteristic of the weighting function: for all $0 < p < 1$, $w(p) + w(1 - p) < 1$. In other words, decision weights do not sum to 1 for choices between two options. Kahneman and Tversky (1979, p. 281) refer to this as *subcertainty*, and this property of the weighting function is somewhat controversial (Abelson & Levi, 1985, pp. 250–251).[7]

It is important to note that attitudes toward risk are not determined by the S-shaped value function alone, as is commonly assumed in most applications of prospect theory to international relations. Rather, risk propensities are determined jointly by the value function and probability weighting function. In the domain of gains where perceived probabilities are above the transition point from overweighting to underweighting (where the weighting function crosses the 45-degree diagonal, at approximately $p = .10 - .15$), the underweighting of probabilities works together with the concavity of the value function to undervalue the gamble relative to the certain outcome, and thus to encourage risk aversion. In the domain of losses, the underweighting of probabilities (above the probability transition point) reduces the weights given to risky negative prospects, makes them less unattractive, and thus encourages risk-seeking. In these probability ranges, the effects of the value function and the probability weighting function are thus mutually reinforcing.

This is not the case where probabilities are small, below the transition point from overweighting to underweighting (but above the very small region in which the value function is not well-behaved). Here the overweighting of probabilities works to increase the value of positive gambles and to increase the negative value of negative gambles, and thus to encourage risk-seeking in the domain of gains and risk aversion in the domain of losses, tendencies which are contrary to the effects of the value function. Which of these counteracting tendencies will dominate depends on the precise shapes of these functions over this range of small probabilities.

It is easy to show that the overweighting of probabilities is a necessary but not sufficient condition for risk-seeking in the domain of gains and for risk

[7]Subcertainty leads to an interesting paradox. Consider a choice between (1) \$100 with certainty and (2) a fair coin flip which yields \$100 for heads and \$100 for tails. Subcertainty and the underweighting of the probabilities in the second option would lead to a preference for the first option, even though the two are mathematically equivalent. The paradox can be removed if editing by combination or cancellation is allowed. This demonstrates why editing is a necessary component of prospect theory (Abelson and Levi, 1985, p. 250).

aversion in the domain of losses. Given the shape of the weighting function and the transition point, this means that for prospect theory the "reversal" of risk propensities can occur only in the range of small probabilities. Whether it will occur in this range depends, however, on the relative shapes of the value and probability weighting functions. The indeterminacy of risk orientation is compounded in the range of extremely small probabilities, where the value function is still concave for gains and convex for losses but where the probability weighting function is indeterminant.

As Kahneman and Tversky (1979, pp. 285–286) note, the conditions for risk acceptance in the domain of gains and risk aversion in the domain of losses (i.e., small probabilities) are precisely those under which lottery tickets and insurance policies are sold. Thus the overweighting (and perhaps the exaggeration) of small probabilities is one possible explanation for the appeal of long-shot gambling, and it also might reinforce the tendency for risk averse individuals to insure against rare but catastrophic losses (Payne et al., 1981; Tversky & Kahneman, 1986, p. S258).[8]

Thus prospect theory challenges some basic assumptions and propositions of expected-utility theory and provides an important alternative theoretical framework for the analysis of social and political behavior. The theoretical and empirical studies in this issue are among the first comprehensive efforts to apply prospect theory to international relations and foreign policy.

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[8]We know, however, that while some people are highly risk-averse with respect to rare catastrophes and overinsure against them, other people basically ignore such potential catastrophes altogether. The unpredictability of behavior involving rare disasters is illustrated by the vast range of responses to the risks of airline disasters, earthquakes, or AIDS. Studies of insurance behavior often find a tendency to insure against losses in the medium range of probabilities but not against rare catastrophes (Slovic et al., 1977; Kunreuther et al., 1978), although these findings have been challenged by others (Hershey & Shoemaker, 1980a). Moreover, there is some evidence that decisions regarding the purchase of insurance are quite sensitive to relatively minor changes in the formulation (or framing) of the problem (Slovic et al., 1977).

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