Medical Decision Making
http://mdm.sagepub.com

Can Prospect Theory Explain Risk-Seeking Behavior by Terminally Ill Patients?

Emma B. Rasiel, Kevin P. Weinfurt and Kevin A. Schulman

Med Decis Making 2005; 25; 609
DOI: 10.1177/0272989X05282642

Can Prospect Theory Explain Risk-Seeking Behavior by Terminally Ill Patients?

Emma B. Rasiel, PhD, Kevin P. Weinfurt, PhD, Kevin A. Schulman, MD

Patients with life-threatening conditions sometimes appear to make risky treatment decisions as their condition declines, contradicting the risk-averse behavior predicted by expected utility theory. Prospect theory accommodates such decisions by describing how individuals evaluate outcomes relative to a reference point and how they exhibit risk-seeking behavior over losses relative to that point. The authors show that a patient's reference point for his or her health is a key factor in determining which treatment option the patient selects, and they examine under what circumstances the more risky option is selected. The authors argue that patients' reference points may take time to adjust following a change in diagnosis, with implications for predicting under what circumstances a patient may select experimental or conventional therapies or select no treatment. ***Key words:*** *decision theory; life expectancy; risk-taking; terminally ill.* ***(Med Decis Making 2005;25:609–613)***

Considerable evidence suggests that the standard model of expected utility, although convenient for its mathematical tractability, is inconsistent with observed human behavior. Individuals appear to show preferences over changes in value relative to a reference point, rather than over absolute levels of value. People exhibit risk-seeking behavior under certain conditions (e.g., for small- or medium-sized losses), in violation of the concavity assumption of expected utility theory (EU).

Researchers have developed several alternative models of human preferences to explain systematic violations of EU. Among the most well-known models are rank-dependent EU, regret theory, and prospect theory. Perhaps the most widely accepted of these models is prospect theory,[1,2] which has been applied in a broad range of decision-making contexts, including economics, law, politics, and health care. In this article, we demonstrate that risk-seeking treatment choices by patients with life-threatening conditions—some of whom select experimental therapies rather than conventional therapies—are consistent with prospect-theory preferences. We also show that identification of a patient's reference point is critical in determining whether the patient will choose riskier or more traditional treatments.

PROSPECT THEORY

Since the development of prospect theory in 1979, a considerable amount of literature that seeks to explain a broad range of human behavior using the theory's tenets has arisen (see Hastie and Dawes[3] for a detailed review). Most of this research relates to decision making in business and economics[4,5]; there has been relatively little research in this area in the medical literature. However, there have been a few recent studies that draw on concepts of prospect theory. Yaniv[6] compared predictions of prospect theory, EU, and regret theory to the dilemma faced by physicians who must decide how much information to disclose to critically ill patients. Lenert and others[7] demonstrated how the prospect-theory value function might explain why patients and the general public report different prefer-

Received 18 June 2004 from the Center for Clinical and Genetic Economics, Duke Clinical Research Institute, Duke University Medical Center, Durham, NC (EBR, KPW, KAS); and the Department of Economics, Duke University, Durham, NC (EBR). Dr. Rasiel was supported in part by a postdoctoral research fellowship awarded by Johnson & Johnson. Revision accepted for publication 7 July 2005.

Address correspondence to Kevin A. Schulman, MD, Center for Clinical and Genetic Economics, Duke Clinical Research Institute, Durham, NC 27715; e-mail: kevin.schulman@duke.edu.

DOI: 10.1177/0272989X05282642

ences for health conditions. There is also anecdotal evidence suggesting that patients may become risk-seeking as health declines[8] and may even make treatment decisions that their physicians report they would not make themselves.[9,10] For example, some patients with cancer choose aggressive or investigational treatment rather than conventional therapy, even though the former carries greater risk of morbidity.[6]

In this article, we consider patients' treatment choices assuming prospect-theory preferences, in which risk-seeking behavior depends on the location of the reference point between gains and losses rather than on values for each treatment outcome.

Reference Points

Our 1st task is to identify an appropriate outcome metric for the reference point. In economics, the reference point is typically chosen over wealth or other monetary equivalents. It is less clear how to measure "value" in health care, as there may be several determining factors (e.g., length of life, quality of life). Current health status is often used as the default reference point (e.g., Lenert and others[7]), although the "aspiration level of survival" may also be appropriate.[11] In this article, we assume that prospect theory "values" are measured with respect to a single attribute—life expectancy. There is also evidence that a patient's reference point for life expectancy (or prognosis) evolves, both over time and in response to new information about the patient's health. Dolan[12] found that both current and past health influenced valuation as measured by EuroQol scores, although he also observed that the impact of past illness weakened significantly over time. There is also direct empirical evidence of reference-level shifts within individual patients. For example, Christensen-Szalanski[13] found that pregnant women's views of anesthesia during labor changed according to whether the patient was experiencing labor pain.

Although diagnosis of a life-threatening condition may result in an immediate and significant decrease in life expectancy, the patient's reference point may respond slowly as the patient comes to terms with the change in prognosis. We hypothesize that a newly diagnosed patient experiences a period of "recalibration" of life expectancy and that the patient's reference level for remaining years of life decreases throughout this period. Depending on how long the recalibration takes, it is reasonable to suppose that the patient's life-expectancy reference level may lie anywhere between its prediagnosis peak and its disease-acceptance trough, at a time when the patient must make a significant treatment choice. A patient who has had multiple occurrences of cancer, on the other hand, may have already become reasonably well-calibrated to more realistic levels.[10]

The prospect-theory model of individuals' preferences replaces the standard concave utility function with a value function that measures changes relative to a reference point. The value function is concave over gains and convex over losses and is steeper in the domain of losses. The prospect-theory value function is parameterized as follows:

$$v(x) = \begin{cases} (x)^{\alpha} & x \geq 0 \\ (-\lambda)(-x)^{\alpha} & x < 0, \end{cases} \tag{1}$$

where x is the outcome gain or loss relative to the reference point, λ is the coefficient of loss aversion (i.e., the extent to which individuals are more sensitive to losses relative to gains of equal magnitude), and α is the curvature of the utility function.

Implications of a Shifting Reference Point

We provide a simple graphical example to motivate the analysis that follows. In Figure 1, we compare the value function of a patient who has been diagnosed recently with a life-threatening condition and was previously in full health, with a life expectancy of 30 years, to that of a patient with a similar medical condition but whose reference point is now calibrated to more realistic levels. As discussed above, we use life expectancy as a proxy for prognosis.

The left-hand panel of Figure 1 shows the prospect-theory value function for the recently diagnosed patient, whose prognosis reference point equals the prediagnosis life expectancy (approximately 30 years). For this patient, all other prognoses are viewed as losses; hence, the value function is convex and is steepest (i.e., has greatest marginal utility) close to the current reference point. The right-hand panel of Figure 1 shows the value function for a terminally ill patient who has had some time to adapt to his or her condition and whose life-expectancy reference point is 5 years. Note that this reference point may or may not equal actual life expectancy, depending on how recently the patient was diagnosed, the patient's health before the recent diagnosis, and other factors that influence the extent to which the patient has "adapted" to current life expectancy.

The key to understanding the implications of moving reference points lies in the measurement of relative values of life-expectancy outcomes. To demonstrate

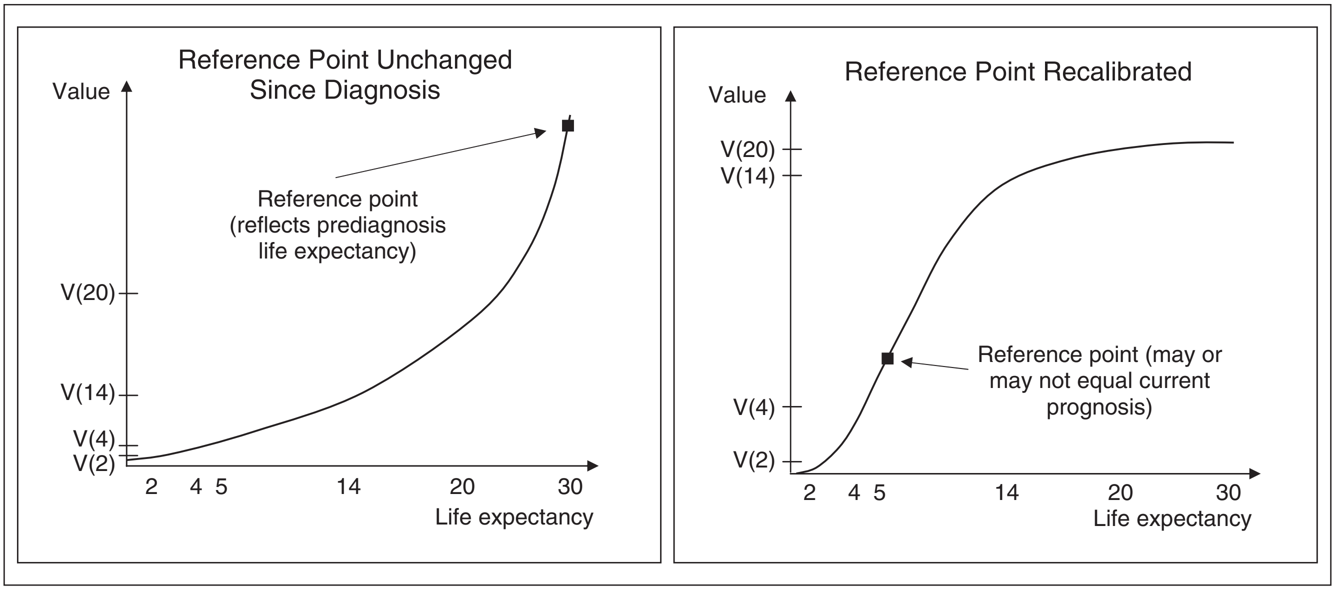

Figure 1 Prospect-theory value functions for 2 patients with a life-threatening illness given different reference points.

this point, we will compare value differences between a pair of relatively low life expectancies (2 and 4 years) and 2 higher values (14 and 20 years). Note that, for the recently diagnosed patient (left-hand panel in Figure 1), the difference in value between life expectancies of 2 and 4 years is very small (vertical axis in Figure 1), whereas the difference in value between 14 and 20 years is greater because those values are closer to the patient's reference point. This is an example of the diminishing sensitivity of the prospect-theory value function. With an expected life span of 30 years, this patient views both a 2-year life span and a 4-year life span as having little value but does not distinguish greatly between them. For the patient who has had some time to adapt to his or her condition, the value difference between 2 and 4 years is much greater because those life expectancies are closer to the patient's current reference point (5 years), whereas the difference between 14 and 20 years is small because those life expectancies are far from the patient's reference point.

Patient Decision Making Under Prospect Theory and EU

In this section, we calibrate patient decision making to the prospect-theory value function and compare optimal choices under different reference-point assumptions to those made by EU maximizers (who are assumed to have power-utility functions with risk-aversion coefficient λ). We consider a hypothetical patient—a 50-year-old woman who has been diagnosed recently with inflammatory breast cancer and has thus experienced a significant negative change in her clinical diagnosis. Before diagnosis, the patient was expected to live to age 78. She now has a 5-year life expectancy without treatment. We assume for simplicity that the patient faces 2 treatment options—investigational (such as a phase-1 clinical trial) and conventional (standard chemotherapy).

Using life expectancy as a quantitative proxy for prognosis, we simplify the analysis further by considering only 2 mutually exclusive outcomes for the active treatment options—success, in which life expectancy is restored to some proportion of the life expectancy before the recent clinical change, and failure, in which treatment toxicity further reduces life expectancy. Conventional therapy is assumed to have a 25% probability of success and, if successful, would restore 50% of the patient's prediagnosis life expectancy (i.e., she would expect to live another 14 years). However, side effects from conventional therapy, if unsuccessful, would reduce current life expectancy to 4 years.

The patient's oncologist has also informed her that there is an investigational study relating to her type of cancer and that she would likely qualify as a candidate for the experimental therapy. The investigational therapy also offers a 25% success probability and, if successful, would restore 70% of previous life expectancy (i.e., she would be expected to live approximately 20 years). However, side effects from experimental therapy are much more severe. If treatment is unsuccessful, the patient will likely die in about 2 years. (For purposes of the analysis, we assume individuals are calibrated correctly to the "objective" probabilities given in the example.)

RESULTS

Assuming prospect-theory preferences with $\alpha = 0.7$ and $\lambda = 2$ (Equation 1), we calculate the patient's prospective value for each option for a range of reference points. For high reference points, when the recently diagnosed patient has not yet adapted to her new prognosis, the prospective value of the investigational therapy exceeds that of the conventional therapy. Specifically, for reference points greater than approximately 13 years, the patient chooses investigational therapy, "gambling" on the 25% probability of restoring life expectancy to somewhat near prediagnosis levels (Figure 2). As the reference point decreases, however, the prospective value of the investigational therapy declines relative to conventional therapy.

Under EU, conventional therapy is always preferable to the investigational therapy. Indeed, we need not calculate the utility values in this case; it is enough to observe that the probability-weighted expected value of the conventional therapy is 6.5 years, higher than that of the investigational therapy (6.4 years). Thus, even if the patient is risk neutral, she will select the conventional therapy under EU. Given any level of risk aversion, of course, this lower-risk choice is reinforced by the concavity of the patient's utility function.

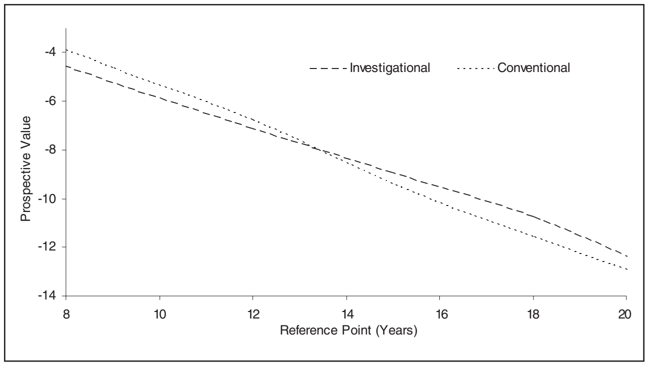

Figure 2 Prospect theory utility ("prospective value") for different treatment options given different reference points.

DISCUSSION

Prospect theory has been used to explain violations of normative EU in a broad range of circumstances. We applied one of the key predictions of prospect theory—that people are risk seeking in the domain of losses—to explain why some terminally ill patients make risky treatment decisions. The model is flexible enough to permit different decisions by patients with similar treatment outcome possibilities, based on their subjective selection of a "reference point" between gains and losses. We propose that the reference point differs among patients depending on prediagnosis and postdiagnosis life expectancies and that it also varies for a given patient over time, assuming that patients do not adapt immediately to a new prognosis. (Of course, there may be many other factors affecting patients' responses to significant medical change and hence their reference points, such as family and career concerns, income and wealth, and so on.)

Our analysis has implications for predicting under what circumstances a patient may select experimental or conventional therapies or select no treatment. The findings may be useful for physicians, who have the difficult task of deciding how much information to provide and which treatment option(s) to suggest after diagnosis. For example, Langer notes that, in the case of breast cancer, "many women are unprepared or unable to optimize adjuvant treatment decisions while experiencing the shock and dismay that often follow the confirmation of [the] diagnosis."[14(p125)] An understanding of how a patient's treatment choices may change over time, as a function of the magnitude of the change in life expectancy, may be of great help to physicians.

There are also implications for recruitment into early-phase clinical trials. Experimental therapies are considered highly risky, with low success probabilities, and recruiting patients can be a slow and difficult process. A better understanding of the circumstances in which patients might make risk-seeking choices would be of considerable value to clinical researchers.

Our hypothetical calibration of the prospect-theory value function also makes a number of assumptions and leaves many questions unanswered. For example, we assume that the patient's reference level is bounded above by prediagnosis life expectancy and below by the postdiagnosis level assuming no treatment, but we have offered no analytic framework for how the level changes over time. We also leave open the question of how to elicit a consistent measure of a patient's view of his or her prognosis and ignore the important issue of adjusting for patient bias in judgment of treatment success probabilities. We leave analysis of these issues to future research.

ACKNOWLEDGMENT

The authors thank Damon Seils for editorial assistance and article preparation and John W. Payne, PhD, for providing comments on an early draft of the article.

REFERENCES

1. Tversky A, Kahneman D. Advances in prospect theory: cumulative representation of uncertainty. J Risk Uncertain. 1992;5:297–323.
2. Kahneman D, Tversky A. Prospect theory: an analysis of decision under risk. Econometrica. 1979;47:263–91.
3. Hastie R, Dawes RM. Rational Choice in an Uncertain World: The Psychology of Judgment and Decision Making. Thousand Oaks: Sage; 2001.
4. Stiggelbout AM, Klebert GM, Kievit J, Leer JWH, Stoter G, De Haes JCJM. Utility assessment of cancer patients: adjustments of time tradeoff scores for the utility of life years and comparison with standard gamble scores. Med Decis Making. 1994;14:82–90.
5. Mazur DJ, Hickam DH. Patient preferences: survival vs quality-of-life considerations. J Gen Intern Med. 1993;8:374–7.
6. Yaniv G. Withholding information from cancer patients as a physician's decision under risk. Med Decis Making. 2000;20:216–27.
7. Lenert LA, Treadwell JR, Schwartz CE. Associations between health status and utilities: implications for policy. Med Care. 1999;37:479–89.
8. O'Connor A. Effects of framing and level of probability on patients' preferences for cancer chemotherapy. J Clin Epidemiol. 1989;42:119–26.
9. Meropol NJ, Weinfurt KP, Burnett CB, et al. Perceptions of patients and physicians regarding phase I cancer clinical trials: implications for physician-patient communication. J Clin Oncol. 2004;21: 2589–96.
10. Gaskin DJ, Weinfurt KP, Castel LD, et al. An exploration of relative health stock in advanced cancer patients. Med Decis Making. 2004;24:614–24.
11. Miyamoto JM, Eraker SA. A multiplicative model of the utility of survival duration and health quality. J Exp Psychol Gen. 1988;117:3–20.
12. Dolan P. The effect of experience of illness on health state valuations. J Clin Epidemiol. 1997;49:551–64.
13. Christensen-Szalanski JJ. Discount functions and the measurement of patients' values: women's decisions during childbirth. Med Decis Making. 1984;4:47–58.
14. Langer AS. Side effects, quality-of-life issues, and trade-offs: the patient perspective. J Natl Cancer Inst Monogr. 2001;30:125–9.