
Anomalies: Preference Reversals

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Anomalies

Preference Reversals

Amos Tversky and Richard H. Thaler

Economics can be distinguished from other social sciences by the belief that most (all?) behavior can be explained by assuming that agents have stable, well-defined preferences and make rational choices consistent with those preferences in markets that (eventually) clear. An empirical result qualifies as an anomaly if it is difficult to “rationalize,” or if implausible assumptions are necessary to explain it within the paradigm. This column will present a series of such anomalies. Readers are invited to suggest topics for future columns by sending a note with some references to (or better yet copies of) the relevant research. Comments on anomalies printed here are also welcome. The address is: Richard Thaler, c/o *Journal of Economic Perspectives*, Johnson Graduate School of Management, Malott Hall, Cornell University, Ithaca, NY 14853.

Introduction

Imagine, if you will, that you have been asked to advise the Minister of Transportation for a small Middle Eastern country regarding the choice of a highway safety program. At the current time, about 600 people per year are killed in traffic accidents in that country. Two programs designed to reduce the number of casualties are under consideration. Program *A* is expected to reduce the yearly number of casualties to 570; its annual cost is estimated at \$12 million. Program *B* is expected to

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reduce the yearly number of casualties to 500; its annual cost is estimated at \$55 million. The Minister tells you to find out which program would make the electorate happier.

You hire two polling organizations. The first firm asks a group of citizens which program they like better. It finds that about two-thirds of the respondents prefer Program *B* which saves more lives, though at a higher cost per life saved. The other firm uses a “matching” procedure. It presents respondents with the same information about the two programs except that the cost of Program *B* is not specified. These citizens are asked to state the cost that would make the two programs equally attractive. The polling firm reasons that respondents’ preferences for the two programs can be inferred from their responses to this question. That is, a respondent who is indifferent between the two programs at a cost of less than \$55 million should prefer *A* to *B*. On the other hand, someone who would be willing to spend over \$55 million should prefer Program *B*. This survey finds, however, that more than 90 percent of the respondents provided values smaller than \$55 million indicating, in effect, that they prefer Program *A* over Program *B*.

This pattern is definitely puzzling. When people are asked to choose between a pair of options, a clear majority favors *B* over *A*. When asked to price these options, however, the overwhelming majority give values implying a preference for *A* over *B*. Indeed, the implicit value of human life derived from the simple choice presented by the first firm is more than twice that derived from the matching procedure used by the other firm.

What are you going to tell the Minister? You decide to call a staff meeting where various explanations for the results are offered. Perhaps one of the pollsters has made a mistake. Perhaps people cannot think straight about problems involving the value of a human life, especially in the Middle East. However, one staff member points out that there is a good reason to trust both surveys, since recent research by some psychologists¹ has produced exactly the same pattern using a wide range of problems such as selecting job applicants, consumer products, and saving plans. The psychologists conclude that the notion of preference that underlies modern decision theory is more problematic than economists normally assume because different methods of elicitation often give rise to systematically different orderings. Well? The Minister is waiting.

For almost two decades, economists and psychologists have been intrigued by a similar inconsistency involving risky prospects. Subjects are first asked to choose between two gambles with nearly the same expected values. One gamble, called the *H* bet (for high chance of winning) has a high chance of winning a relatively small prize (say, 8/9 chance to win \$4), while the other gamble, the *L* bet, offers a lower chance to win a larger prize (say, a 1/9 chance to win \$40). Most subjects choose the *H* bet.

¹See Tversky, Sattath, and Slovic (1988). The data regarding the two highway safety programs are taken from this paper.

Subjects are then asked to price each of the gambles. Specifically, they are asked to state the lowest price at which they would be willing to sell each gamble if they owned it. Surprisingly, most subjects put a higher price on the *L* bet. (In a recent study that used this particular pair of bets, for example, 71 percent of the subjects chose the *H* bet, while 67 percent priced *L* above *H*.) This pattern is called a *preference reversal*. Sarah Lichtenstein and Paul Slovic (1971, 1973) first demonstrated such reversals in a series of studies, one of which was conducted for real money with gamblers on the floor of the Four Queens Casino in Las Vegas.

Lichtenstein and Slovic did not come upon this result by chance. In an earlier study (Slovic and Lichtenstein, 1968), they observed that both buying and selling prices of gambles were more highly correlated with payoffs than with chances of winning, whereas choices between gambles (and ratings of their attractiveness) were more highly correlated with the probabilities of winning and losing than with the payoffs. The authors reasoned that if the method used to elicit preferences affected the weighting of the gamble's components, it should be possible to construct pairs of gambles such that the same individual would choose one member of the pair but set a higher price for the other. Experimental tests supported this conjecture.

The preference reversal phenomenon raises an issue rarely discussed in economics: How is the notion of preference to be operationalized? We say that option *A* is preferred to option *B* if *A* is selected when *B* is available *or* if *A* has a higher reservation price than *B*. The standard analysis of choice assumes that these procedures give rise to the same ordering. This requirement—called procedure invariance—seldom appears as an explicit axiom, but it is needed to ensure that the preference relation is well defined. The assumption of procedure invariance is not unique to the study of preference. When measuring mass, for example, we can use either a pan balance or a spring to determine which of the objects is heavier, and we expect the two measurement procedures to yield the same ordering. Unlike the measurement of physical attributes such as mass or length, however, different methods of eliciting preference often give rise to systematically different orderings. This column summarizes the evidence regarding this puzzling result, and discusses its implications for economics.

Economists were introduced to the preference reversal phenomenon by David Grether and Charles Plott (1979) who designed a series of experiments “to discredit the psychologists’ work as applied to economics” (p. 623). These authors began by generating a list of 13 objections and potential artifacts that would render the preference reversal phenomenon irrelevant to economic theory. Their list included poor motivation, income effects, strategic responding, and the fact that the experimenters were psychologists (thereby creating suspicions leading to peculiar behavior). Grether and Plott attempted to eliminate preference reversals by various means (like offering a special incentive system), but to no avail. Indeed, preference reversals were somewhat more common among subjects responding under financial incentives than in a control group facing purely hypothetical questions. Subsequent studies by both psychologists and economists, using a wide range of procedural variations, led to

similar conclusions. (See Slovic and Lichtenstein (1983) for a review of the early literature and Tversky, Slovic and Kahneman (1990) for later references.)

Although these experimental studies have established the validity and the robustness of the preference reversal phenomenon, its interpretation and explanation has remained unclear. To formulate the problem, we must introduce some notation. Let C_H and C_L denote the cash equivalents (or minimum selling price) of H and L (the gambles with high and low chances of winning, respectively). Let \succ and \approx denote strict preference and indifference, respectively. Recall that a preference reversal occurs when H is preferred to L but L is priced higher than H ; that is, $H \succ L$ and $C_L > C_H$. Note that \succ refers to preference between options, whereas $>$ refers to the ordering of cash amounts.² It is not difficult to see that a preference reversal implies either the intransitivity of the preference relation, \succ , or a failure of procedure invariance, or both. Now, recall that if procedure invariance holds, a decision maker will be indifferent when choosing between a bet B and some cash amount X , if and only if the cash equivalent for B is equal to X , that is $C_B = X$. So, if procedure invariance holds, then a preference reversal implies the following intransitive pattern of preferences:

$$C_H \approx H \succ L \approx C_L > C_H$$

where the two inequalities are implied by the assumed preference reversal and the two equivalences follow from procedure invariance.

Because procedure invariance is commonly taken for granted, many authors have interpreted preference reversals as intransitivities, and some have proposed nontransitive choice models to account for this phenomenon (Loomes and Sugden, 1983; Fishburn, 1985). A preference reversal, however, does not imply cyclic choice; it can be consistent with transitivity if procedure invariance does not hold. Two types of discrepancies between choice and pricing could produce the standard pattern of preference reversal,³ that is, preferring H but assigning a higher value to L : either overpricing of L or underpricing of H . Overpricing of L is evident if the decision maker prefers her reservation price for the bet over the bet itself when offered a choice between them on another occasion (i.e., $C_L \succ L$). Underpricing of H is evident if the decision maker prefers the bet over its price in a direct choice on another occasion (i.e., $H \succ C_H$). (The terms overpricing and underpricing merely identify the sign of the discrepancy between pricing and choice; the labels are not meant to imply that the choice represents one's "true" preference and the bias resides in pricing.)

The third possible explanation of the preference reversal implicates the payoff scheme used to elicit cash equivalence. To encourage subjects to produce careful and

²We assume that for sure outcomes measured in dollars $X > Y$ implies $X \succ Y$; that is, more money is preferred to less.

³This is the standard preference reversal pattern. The other possible preference reversal, choosing L but assigning a higher value to H is rarely observed. We use the term "preference reversal" to refer to this standard pattern.

truthful responses, several investigators have employed the following payoff scheme called the BDM procedure after its originators Becker, DeGroot and Marschak (1964). After the subject states a selling price for a gamble, an offer is generated by some random process. The subject receives the offer if it exceeds the stated selling price, and plays the gamble if the stated price exceeds the offer. The price stated by the subject, therefore, serves only to determine whether the subject will play the bet or receive the cash, but it does not determine the actual amount. As long as the subject is an expected utility maximizer, this procedure is incentive compatible: the decision maker has no incentive to state a selling price that departs from his or her actual cash equivalent. However, as noted by Holt (1986), Karni and Safra (1987), and Segal (1988), if the decision maker does not obey the independence (or reduction) axiom of expected utility theory, the BDM procedure no longer ensures that the stated price will correspond to the cash equivalent of the gamble. Indeed, Karni and Safra have shown that preference reversals observed under the BDM scheme are consistent with a generalized version of expected utility theory with nonlinear probabilities.

So we now have three alternative interpretations of preference reversals. They can arise from violations of transitivity, procedure invariance, or the independence axiom. To determine which interpretation is correct we need to solve two problems. First, we need an experimental procedure that can distinguish between failures of transitivity and failures of procedure invariance. Second, we need an incentive-compatible payoff scheme that does not rely on the expectation principle. Both requirements have been met in a recent study by Tversky, Slovic and Kahneman (1990).

To discriminate between the intransitivity and procedure invariance explanations, these investigators extended the original design to include, in addition to the standard H and L bets, a cash amount X that was compared to both of them. That is, subjects indicated their preferences between each of the pairs in the triple $\{H, L, X\}$. Subjects also produced cash equivalents, C_L and C_H , (using a method described below) for both of the bets. By focusing on standard preference reversal patterns in which the pre-specified cash amount X happened to lie between the values of C_L and C_H generated by this subject (that is, $H > L$ and $C_L > X > C_H$), it is possible to diagnose each preference reversal pattern according to whether it was produced by an intransitivity, by an overpricing of L , by an underpricing of H , or by both. For example, if subjects indicated that $L > X$, and that $X > H$, then their preferences are intransitive since we are confining our attention to those cases in which $H > L$. Alternatively, if subjects overprice the L bet, then their pattern of responses will be $X > L$ and $X > H$. (The subjects produce a price for L that is greater than X , but when offered a choice between X and L , they choose X .) This pattern is transitive, though it is a preference reversal.

The results of this study were very clear. Using 18 triples of the form $\{H, L, X\}$ that cover a wide range of payoffs, the experiment yielded the usual rate of preference reversal (between 40 and 50 percent), but only 10 percent of preference reversal patterns were intransitive, and the remaining 90 percent violated procedure invari-

ance. By far, the major source of preference reversal was the overpricing of the L bet, which accounted for nearly two-thirds of the observed patterns. (Note that if subjects were choosing at random, the expected rate of the standard preference reversal is 25 percent.)

Having eliminated intransitivity as the major cause of preference reversal, let us turn now to the effect of the payoff scheme. Karni and Safra (1987) have shown that it is exceedingly difficult, if not impossible, to devise an incentive compatible payoff scheme for the elicitation of cash equivalence that does not rely on expected utility theory. Fortunately, to demonstrate preference reversal, it is not necessary to elicit the actual selling prices; it is sufficient to establish their order—which can be obtained under much weaker conditions. Suppose the subject is presented with two tasks: pricing each bet separately and choosing between pairs of bets. The subjects are told that one of these pairs will be selected at random at the end of the session, and that they will play one of these bets. To determine which bet they will play, first a random device will be used to select either choices or pricing as the criteria for selection. If the choice data are used, then the subject plays the bet chosen. If the pricing data are used, then the subject will play whichever gamble was priced higher.

In this latter procedure, called the *ordinal payoff scheme*, the prices offered by the subjects are only used to order the bets within each pair. Consistency, therefore, requires that the price orderings and choice orderings should agree, whether or not the subjects are expected utility maximizers. Thus, if the previously observed reversals were caused by a failure of expected utility theory, then they should not occur under the ordinal payoff scheme. This prediction was clearly refuted. The incidence of reversals was roughly the same (40 percent to 50 percent) whether the experiment employed the BDM scheme, the above ordinal scheme, or even no payoff scheme at all. This finding shows that preference reversal is not caused by the BDM procedure, hence it cannot be explained as a violation of the independence or reduction axioms of expected utility theory.

The conclusions of the Tversky, Slovic, and Kahneman study may be summarized as follows. First, intransitivity alone accounts for only a small portion of preference reversal patterns. Second, preference reversal is hardly affected by the payoff scheme, hence, it is not attributable to the failure of expected utility theory. Third, the major cause of preference reversal is the failure of procedure invariance and, more specifically, the overpricing of the L bets. That is, the minimum selling prices associated with L bets (but not with H bets) are too high in comparison to the choices between the bets and cash amounts. These conclusions are further supported by a recent study of Bostic, Herrnstein and Luce (1990) using a somewhat different design.

This analysis raises a new question: Why do people overprice the low-probability high-payoff bets? Why do people who prefer, say, \$10 for sure over a $1/3$ chance to win \$40, assign to this bet a cash equivalent that exceeds \$10? Research suggests that this counterintuitive finding is a consequence of a general principle of compatibility that appears to play an important role in human judgment and choice.

The Compatibility Hypothesis

The concept of stimulus-response compatibility has been introduced by students of human factors who studied perceptual and motor performance. For example, a square array of four burners on a stove is easier to control with a matching square array of knobs than with a linear array. Slovic, Griffin, and Tversky (1990) have extended this concept and proposed that the weight of a stimulus attribute in judgment or in choice is enhanced by its compatibility with the response scale. The rationale for this scale compatibility hypothesis is two-fold. First, if the stimulus and the response do not match, additional mental operations are needed to map one into the other. This increases effort and error and may reduce the impact of the stimulus. Second, a response mode tends to focus attention on the compatible features of the stimulus. Because there is neither a formal definition of compatibility nor an independent measurement procedure, the analysis is both informal and incomplete. Nevertheless, in many contexts the compatibility order is sufficiently clear so that it can be investigated experimentally.

A simple study by Slovic, Griffin, and Tversky illustrates a case in which the compatibility hypothesis makes a clear prediction. Subjects were given two pieces of information about each of 12 large companies taken from *Business Week*'s Top 100: the company's 1986 market value (in billions of dollars), and the company's rank (among the Top 100) with respect to 1987 profits. Half of the subjects were then asked to predict the 1987 market value in billions of dollars, whereas the other half were asked to predict the company's rank with respect to its 1987 market value. Thus each subject has one predictor measured on the same scale (that is, money or rank) as the dependent variable, and one predictor measured on a different scale. As implied by compatibility, each predictor was given more weight when the predicted variable was expressed on the same scale. As a consequence, the relative weight of the 1986 market value was twice as high for those who predicted in dollars than for those who predicted the corresponding rank. This effect produced many reversals in which one company was ranked above another but the order of their predicted values was reversed.

Because the cash equivalence of a bet is expressed in dollars, compatibility implies that the payoffs, which are expressed in the same units, will be weighted more heavily in pricing bets than in choosing between bets. Furthermore, since the payoffs of L bets are much larger than the payoffs of H bets, the major consequence of a compatibility bias is the overpricing of the L bet. The compatibility hypothesis, therefore, explains the major source of preference reversal, namely the overpricing of the low-probability high-payoff bets. This account has been supported by several additional findings. Slovic, Griffin, and Tversky presented subjects with H and L bets involving nonmonetary outcomes, such as a one-week pass for all movie theaters in town, or a dinner for two at a good restaurant. If preference reversals are due primarily to the compatibility of prices and payoffs, which are both expressed in dollars, their incidence should be substantially reduced by the use of nonmonetary

outcomes. This is precisely what happened. The prevalence of preference reversals was reduced by nearly 50 percent. Schkade and Johnson (1989) found additional support for the role of compatibility in preference reversals in a computer-controlled experiment which allowed subjects to see only one component of each bet at a time. The percentage of time spent looking at the payoff was significantly greater in a pricing task than in a choice task. This pattern was pronounced when the subject produced a preference reversal, but not when the subject produced consistent responses. The finding that subjects attend to the payoffs more in pricing than in choice supports the hypothesis that people focus their attention on the stimulus components that are most compatible with the response mode.

Although the compatibility hypothesis can explain preference reversals between pairs of bets, the explanation does not depend on the presence of risk. Indeed, this hypothesis implies a similar discrepancy between choice and pricing for riskless options with a monetary component, such as delayed payments. Let (X, T) be a prospect that offers a payment of $\$X$, T years from now. Consider a long-term prospect L ($\$2500$, 5 years from now) and a short-term prospect S ($\$1600$, $1\frac{1}{2}$ years from now). Suppose that subjects (i) choose between L and S , and (ii) price both prospects by stating the smallest immediate cash payment for which they would be willing to exchange the delayed payment. According to the compatibility hypothesis, the monetary component X would loom larger in pricing than in choice. As a consequence, subjects should produce preference reversals in which the short-term option is preferred over the long-term option in a direct choice, but the latter is priced higher than the former (that is, $S \succ L$ and $C_L > C_S$). This was precisely the pattern observed by Tversky, Slovic and Kahneman (1990). These investigators presented a large group of subjects with pairs of S and L options with comparable present values. The subjects chose between pairs of options, and also priced each option separately. Subjects exhibited the predicted pattern of preference. Overall, subjects chose the short-term option 74 percent of the time but priced the long-term option above the short-term option 75 percent of the time, and the rate of reversals exceeded 50 percent. The incidence of the non-predicted reversals was less than 10 percent. Further analysis revealed that—as in the risky case—the major source of preference reversal was the overpricing of the long-term option, as entailed by compatibility. These findings indicate that the preference reversal phenomenon is an example of a general pattern, rather than a peculiar characteristic of choice between bets.

Indeed, the preference reversal phenomenon is not the only example of a failure of procedure invariance. As illustrated by the life-saving example discussed in the introduction to this article, Tversky, Sattath and Slovic (1988) have demonstrated a related discrepancy between choice and matching. These investigators observed that the more prominent dimension looms larger in choice than in matching. In the highway safety problem, for example, human lives are valued much higher in a direct choice than in the price matching procedure. Recall that in this study subjects selected the program that saved more lives when making a direct choice, but their stated prices favored the less expensive program. As a consequence, choice is more lexicographic

than matching—the most important dimension is weighted more heavily in choice. Other violations of procedure invariance in the context of risky choice have been documented by Hershey and Schoemaker (1985). They first ask subjects to provide a certainty equivalent for some gamble, such as a 50 percent chance to win \$100. Suppose the subject says \$40. Later the subject is asked to indicate what probability of winning \$100 would make the gamble just as attractive as a sure \$40. If procedural invariance holds, then subjects should respond with .5. However, subjects do not reproduce the probability they started with, and their departures are systematic rather than random. Other violations of procedure invariance involving choice and ratings of gambles are presented by Goldstein and Einhorn (1987).

Commentary

Taken at face value the data [showing preference reversals] are simply inconsistent with preference theory and have broad implications about research priorities within economics. The inconsistency is deeper than the mere lack of transitivity or even stochastic transitivity. It suggests that no optimization principles of any sort lie behind the simplest of human choices and that the uniformities in human choice behavior which lie behind market behavior may result from principles which are of a completely different sort from those generally accepted (Grether and Plott, 1979, p. 623).

The preference reversal phenomenon has been established in numerous studies during the last two decades, but its causes have only recently been uncovered. It appears that preference reversals cannot be attributed to an intransitivity or to a violation of the independence axiom of expected utility theory. Rather, they seem to be driven primarily by the discrepancy between choice and pricing, which in turn is induced by scale compatibility. This account is supported by several new experiments, and it gives rise to a new type of reversal in the domain of time preference. What are the implications of preference reversals to economics and decision theory? This phenomenon, or cluster of phenomena, challenges the traditional assumption that the decision maker has a fixed preference order that is captured accurately by any reliable elicitation procedure. If option *A* is priced higher than option *B*, we cannot always assume that *A* is preferred to *B* in a direct comparison. The evidence shows that different methods of elicitation could change the relative weighting of the attributes and give rise to different orderings.

The findings are in contrast to the standard economic formulation of choice which assumes that, in the presence of complete information, people act as if they could look up their preferences in a book, and respond to situations accordingly: choose the item most preferred; pay up to the value of an item to obtain it; sell an item if offered more than its value; and so on. The principle of procedure invariance is

likely to hold under two conditions. First, people could have preestablished preferences. If you prefer football to opera, then this preference will emerge whether you are choosing between activities or bidding for tickets. However, procedure invariance could also hold even if people do not have preestablished preferences. We do not immediately know the value of $7(8 + 9)$, but we have an algorithm for computing it that yields the same answer whether we do the addition before or after the multiplication. The results of the experiments reported here indicate that neither condition holds. First, people do not possess a set of pre-defined preferences for every contingency. Rather, preferences are constructed in the process of making a choice or judgment. Second, the context and procedures involved in making choices or judgments influence the preferences that are implied by the elicited responses. In practical terms, this implies that behavior is likely to vary across situations that economists consider identical. For example, alternative auction mechanisms which are equivalent in theory might produce different outcomes if the auction procedures themselves influence bidding behavior.

The discussion of the meaning of preference and the status of value may be illuminated by the well-known exchange among three baseball umpires. "I call them as I see them," said the first. "I call them as they are," claimed the second. The third disagreed, "They ain't nothing till I call them." Analogously, we can describe three different views regarding the nature of values. First, values exist—like body temperature—and people perceive and report them as best they can, possibly with bias (I call them as I see them). Second, people know their values and preferences directly—as they know the multiplication table (I call them as they are). Third, values or preferences are commonly constructed in the process of elicitation (they ain't nothing till I call them). The research reviewed in this article is most compatible with the third view of preference as a constructive, context-dependent process.

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