Research Report

THE DISJUNCTION EFFECT IN CHOICE UNDER UNCERTAINTY

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Abstract—*One of the basic axioms of the rational theory of decision under uncertainty is Savage's (1954) sure-thing principle (STP) It states that if prospect* x *is preferred to* y *knowing that Event A occurred, and if* x *is preferred to* y *knowing that A did not occur, then* x *should be preferred to* y *even when it is not known whether A occurred We present examples in which the decision maker has good reasons for accepting* x *if A occurs, and different reasons for accepting* x *if A does not occur Not knowing whether or not A occurs, however, the decision maker may lack a clear reason for accepting* x *and may opt for another option We suggest that, in the presence of uncertainty, people are often reluctant to think through the implications of each outcome and, as a result, may violate STP This interpretation is supported by the observation that STP is satisfied when people are made aware of their preferences given each outcome*

Most decisions are made in the presence of uncertainty about their consequences, which may depend on the state of the economy, the outcome of an exam, or the toss of a coin Decision theorists have proposed a number of principles that purport to guide, and perhaps describe, the making of decisions under uncertainty One of the most basic principles of rational choice, which underlies expected utility theory as well as other models, was described by Savage as follows

> A businessman contemplates buying a certain piece of property He considers the outcome of the next presidential election relevant to the attractiveness of the purchase So, to clarify the matter for himself, he asks whether he would buy if he knew that the Republican candidate were going to win and decides that he would do so Similarly he considers whether he would buy if he knew that the Democratic candidate were going to win, and again finds that he would do so Seeing that he would buy in either event he decides that he should buy, even though he does not know which event obtains It is all too seldom that a decision can be arrived at on the basis of the principle used by this businessman but except possibly for the assumption of simple ordering I know of no other extralogical principle governing decision that finds such ready acceptance (Savage 1954, p 21)

Savage went on to define this principle formally If x is preferred to y knowing that event A obtained, and if x is preferred to y knowing that A did not obtain, then x should be preferred to y even when it is not known whether A obtained This rule, which Savage called the *sure-thing principle* (henceforth STP), has a great deal of both normative and descriptive appeal Nevertheless, this principle does not always hold, especially when the decision maker has different reasons for making the same decision in different states of the world, as illustrated in the following example

PAYING TO KNOW

Disjunctive Version

Imagine that you have just taken a tough qualifying examination It is the end of the fall quarter, you feel tired and run-down, and you are not sure that you passed the exam In case you failed you have to take the exam again in a couple of months—after the Christmas holidays You now have an opportunity to buy a very attractive 5-day Christmas vacation package to Hawaii at an exceptionally low price The special offer expires tomorrow, while the exam grade will not be available until the following day Would you

x	buy the vacation package	32%
y	not buy the vacation package	7%
z	pay a $5 nonrefundable fee in order to retain the rights to buy the vacation package at the same exceptional price the day after tomorrow—after you find out whether or not you passed the exam	61%

Sixty-six subjects were presented with this problem, which was presented in written form in a classroom setting, as were all the problems discussed in this article The respondents were undergraduate students at Stanford University, with about an equal number of men and women The percentage of subjects who chose each option appears on the right Two additional versions of the above problem, called Pass and Fail, were presented to two different groups of 67 subjects each These two versions differed only in the passage in brackets

Pass/Fail Version

Imagine that you have just taken a tough qualifying examination It is the end of the semester, you feel tired and run-down, and you find out that you [passed the exam/failed the exam You will have to take it again in a couple of months—after the Christmas holidays] You now have an opportunity to buy a very attractive 5-day Christmas vacation package to Hawaii at an exceptionally low price The special offer expires tomorrow Would you

		Pass	Fail
x	buy the vacation package	54%	57%
y	not buy the vacation package	16%	12%
z	pay a $5 nonrefundable fee in order to retain the rights to buy the vacation package at the same exceptional price the day after tomorrow	30%	31%

As shown, more than half of the students chose the vacation package when they knew that they passed the exam, and a slightly larger percentage chose the vacation when they knew that they failed However, when students did not

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know whether they had passed or failed, less than one third chose the vacation and 61% were willing to pay $5 to postpone the decision until the following day, when the results would be known

An additional group of subjects (N = 123) was presented with both the Fail and the Pass versions (presentation order was randomized) and asked whether they would buy the vacation package in each case Two thirds of the subjects made the same choice in the two conditions, indicating that the response to the disjunctive version cannot be explained by the hypothesis that subjects who like the vacation in case they pass the exam do not like it in case they fail the exam and vice versa Note that while only one third of the subjects made different decisions depending on the outcome of the exam, more than 60% of the subjects chose to wait when the outcome was not known

We attribute this pattern of preference to the loss of acuity induced by the presence of uncertainty Once the outcome of the exam is known, the student has good—albeit different—reasons for taking the trip If the student has passed the exam, the vacation is presumably seen as a reward following a successful semester, if the student has failed the exam, the vacation becomes a consolation and time to recuperate before taking the exam again A student who does not know the outcome of the exam, however, has less clear reasons for going to Hawaii In particular, she may feel certain about wanting to go if she passes the exam, but unsure about whether she would want to go if she fails Furthermore, she may feel it is inappropriate to reward herself with a trip to Hawaii regardless of whether she passes or fails Only when she focuses exclusively on the possibility of passing and of failing the exam does her preference for going to Hawaii become clear The presence of uncertainty, we suggest, tends to blur the picture and makes it harder for people to see through the implications of each outcome Broadening the focus of attention can lead to a loss of acuity

Notice that the outcome of the exam will be known long before the vacation begins However, the uncertainty at the moment of decision about the reasons for taking the vacation discourages many students from buying the package, even when both outcomes ultimately favor this course of action The preceding discussion suggests that STP may fail when (a) the decision maker has different reasons for taking the same course of action, depending on whether a given event does or does not occur, and (b) these reasons are not evident to the decision maker in the presence of uncertainty about the outcome This account is further tested in the following study of choice between risky prospects

Table 1 *Number of subjects (N = 98) who accepted or rejected the second gamble in the disjunctive condition for each of the four groups defined by their choices in the Won and the Lost conditions*

Lost first gamble	Won first gamble: Accept second	Won first gamble: Reject second
Accept second	26 Reject 14 Accept	12 Reject 6 Accept
Reject second	17 Reject 11 Accept	8 Reject 4 Accept

CHOICE UNDER RISK

Won/Lost Version

Imagine that you have just played a game of chance that gave you a 50% chance to win $200 and a 50% chance to lose $100 The coin was tossed and you have [won $200/lost $100]

You are now offered a second identical gamble

50% chance to win $200 and
50% chance to lose $100

Would you

		Won	Lost
x	Accept the second gamble	69%	59%
y	Reject the second gamble	31%	41%

Ninety-eight subjects were presented with the Won version of the problem above, followed a week later by the Lost version, and 10 days after that by the following version that is a disjunction of the previous two

Disjunctive Version

Imagine that you have just played a game of chance that gave you a 50% chance to win $200 and a 50% chance to lose $100 Imagine that the coin has already been tossed but that you will not know whether you have won $200 or lost $100 until you make your decision concerning a second, identical gamble

50% chance to win $200 and
50% chance to lose $100

Would you

x	Accept the second gamble	36%
y	Reject the second gamble	64%

These problems were embedded among several similar problems so that the logical relation among the three versions would not be transparent Subjects were instructed to treat each decision separately The data show that a majority of subjects accepted the second gamble after having won the first gamble, and a majority accepted the second gamble after having lost the first gamble Most subjects, however, rejected the second gamble when the outcome of the first was not known This pattern of preference clearly violates Savage's STP, we call it the *disjunction effect* [1]

A more detailed analysis of individual choices is presented in Table 1 The subjects are divided into four groups those who accepted the second gamble in both the Won and the Lost conditions, those

1 We first noticed this pattern in the context of a hiring decision Having made a job offer to one candidate, a committee was considering another candidate for a second position Members of the committee were intent on making the second offer if the first were declined, they were also intent, for somewhat different reasons, on making it if the first were accepted However, they were not prepared to make the second offer without knowing whether the first was accepted or declined

who rejected the second gamble in both conditions, those who accepted in the Won condition and rejected in the Lost condition, and those who rejected in the Won condition and accepted in the Lost condition. For each group, Table 1 presents the number of subjects who accepted or rejected the second gamble in the disjunctive condition, that is, when the outcome of the first gamble was not known. The table shows that 41% of the subjects (40 out of 98) accepted the second gamble both after a gain and after a loss in the first gamble (see the upper left-hand cell of Table 1). Among these, however, 65% (26 subjects) rejected the second gamble in the disjunctive condition. Indeed, the pattern "accept after a win, accept after a loss, but reject when uncertain" was the single most frequent response, exhibited by 27% of all subjects.

In the absence of error, all subjects in the accept/accept cell of Table 1 should accept the gamble in the disjunctive condition. To estimate the reliability of choice, we presented the basic gamble (accept or reject an even chance to win $200 or lose $100) to a comparable group of subjects twice, several weeks apart. Only 19% of the subjects (N = 95) made different decisions on the two occasions. The 65% rejection rate in the accept/accept cell, therefore, cannot be attributed to unreliability.

We have replicated the disjunction effect in a between-subjects design. Three different groups of 71 subjects were presented with the Won version, the Lost version, and the disjunctive version. As in the within-subjects design, a majority (69%) accepted the gamble in the Won condition, and a majority (57%) accepted the gamble in the Lost condition, but only 38% accepted the gamble in the disjunctive condition. The finding that the distribution of choices was nearly identical in the within-subjects and the between-subjects designs indicates that the respondents in the former study evaluated each version independently, with no detectable effects of one version on the other. An additional group (N = 75) was asked whether they would accept the gamble (even chance to win $200 or lose $100) when there had been no previous play. Only 33% of the subjects accepted the gamble in this condition. A similar rate of acceptance for this gamble (30%, N = 230) was reported previously (Tversky & Bar-Hillel, 1983).

As in the Hawaii scenario discussed earlier, the decision maker has different reasons for accepting the second gamble in the Won and in the Lost conditions. This gamble has a positive expected value, but it also involves the risk of a nontrivial loss. In the Won condition, the decision maker has already made $200, so even a loss on the second gamble leaves him ahead overall, which makes this option quite attractive. In the Lost condition, the decision maker is down $100, so playing the second gamble offers a chance to "get out of the red," which many people find more attractive than accepting a sure loss of $100. In the disjunctive condition, however, the decision maker does not know whether he is up $200 or down $100. Not knowing whether playing the second gamble amounts to a no-loss proposition or a chance to avoid a sure loss, the decision maker lacks a clear reason for playing the second gamble. The uncertainty concerning the first gamble, we suggest, makes it harder to contemplate the implication of each outcome. For example, the decision maker may be sure that he wishes to play the second gamble if he wins the first, but he may be unsure about his preference if he loses the first gamble. Only by focusing exclusively on the latter possibility does the decision maker realize that he wishes to play the second gamble in this case as well.

It could be argued that the observed violation of STP is caused by a general tendency to reject the gamble in the disjunctive condition, regardless of the nature of the reasons for action. To test this hypothesis, we modified the previous problem by adding $400 to both outcomes of the first gamble so that the decision maker cannot lose in either case. Unlike the previous scenario, in which the second gamble amounted to either a no-loss proposition or a chance to avoid a sure loss, in this case the second gamble represents a no-loss proposition regardless of the outcome of the first gamble. The modified problem reads as follows:

> Imagine that you have just played a game of chance that gave you a 50% chance to win $600 and a 50% chance to win $300. Imagine that the coin has already been tossed, but that you will not know whether you have won $600 or $300 until you make your decision concerning a second gamble:
>
> 50% chance to win $200 and
> 50% chance to lose $100

Altogether, 171 subjects were presented with this problem, equally divided into three groups. One group was told that they had won $300 on the first gamble (the low-win version), a second group was told that they had won $600 on the first gamble (the high-win version), and the third group was told that the outcome of the first gamble—$300 or $600—was not known (the disjunctive version). In all cases, subjects had to choose whether to accept or reject a second gamble consisting, as in the original problem, of an even chance to win $200 or lose $100. In this modified problem, the second gamble was chosen about equally often in the disjunctive version (73%) as in the low-win (69%) and the high-win (75%) versions. Evidently, there is no general tendency to reject the gamble in the disjunctive condition. This conclusion is also supported by the earlier finding that the rate of acceptance in the disjunctive condition is similar to the rate observed when there has been no previous play.

A Theoretical Analysis

The disjunction effect can be illustrated using the tree diagram presented in Figure 1. The second gamble, denoted G, is accepted at the upper branch (the Won condition) as well as at the lower branch (the Lost condition). However, the second gamble is rejected in the disjunctive condition, when the subjects do not know which branch they are on. These data can be interpreted in terms of the value function of prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, in press). Figure 2 displays this function, which represents the subjective value of monetary gains and losses. In accord with the principle of diminishing sensitivity, the value function is concave above the origin, giving rise to risk aversion in the domain of gains, and convex below the origin, giving rise to risk seeking in the domain of losses. Furthermore, the function is steeper for losses than for gains, in accord with the principle of loss aversion.

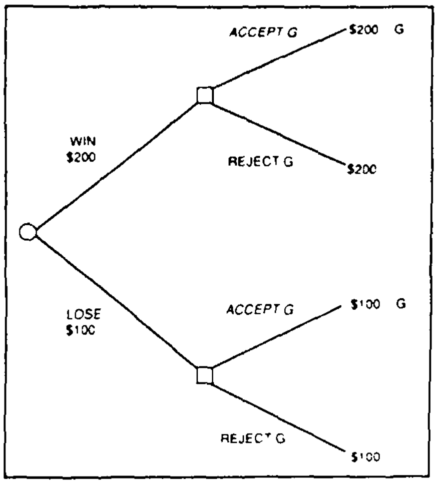

Fig 1 A tree diagram illustrating the disjunction effect Decision nodes are denoted by squares, the chance node is denoted by a circle The modal choices are in italics

Prospect theory also incorporates a weighting function that replaces the stated probabilities of outcomes by some nonadditive measure To simplify the present treatment, we assume that the weights coincide with stated probabilities, but this assumption is not essential for the analysis The function in Figure 2 describes a typical decision maker who is indifferent between a 50% chance of winning $100 and a sure gain of $35, and is also indifferent between a 50% chance of losing $100 and a sure loss of $40

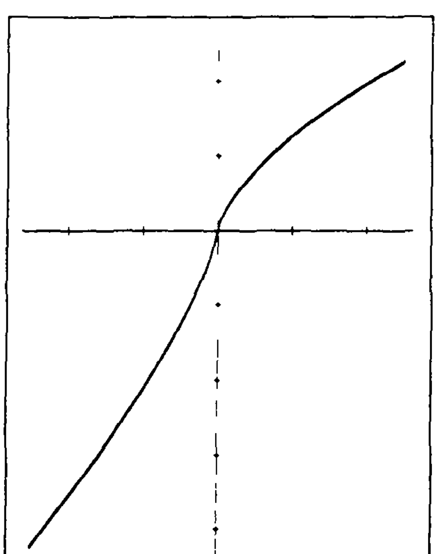

Fig 2 The value function $v(x) = x^{65}$ for $x \geq 0$ and $v(x) = -(-x)^{75}$ for $x \leq 0$

These preferences can be described by a two-part power function with exponents of 65 for gains and 75 for losses

Consider now a decision maker whose values for gains and losses are described by the function of Figure 2 In the Won condition, the decision maker faces a choice between a sure gain of $200 (if he or she rejects the second gamble) and an even chance to receive either $400 or $100 (if he or she accepts the second gamble) According to the value function, the second gamble is acceptable in the Won condition because

$$v(200) < 5v(100) + 5v(400) \text{ since } 200^{65} < 5(100)^{65} + 5(400)^{65}$$

In contrast, in the Lost condition, the decision maker faces the choice between a sure loss of $100 (if he or she rejects the second gamble) and an even chance of winning $100 or losing $200 (if he or she accepts the second gamble) According to the value function again, the second gamble is acceptable in the Lost condition because

$$v(-100) < 5v(100) + 5v(-200) \text{ since } -(100)^{75} < 5(100)^{65} - 5(200)^{75}$$

Thus, if the decision maker takes into account the (known) outcome of the first gamble, the second gamble is acceptable, according to the proposed value function, in both the Won and the Lost conditions In the disjunctive condition, however, we propose that people do not evaluate the second gamble from the two alternative positions, one assuming a gain and one assuming a loss, as implied by STP Instead, not knowing whether they have won or lost the first gamble, people segregate the second gamble and evaluate it from their current position This assumption is supported by the observation that the percentage of subjects who accepted the gamble in the disjunctive version (36%) was similar to that observed when no prior gamble was mentioned (33%) Thus, the second gamble in the disjunctive condition is evaluated as an equal chance to win $200 or lose $100 Because of loss aversion, this gamble is not acceptable

$$5v(200) + 5v(-100) < 0 \text{ since } 200^{65} < 100^{75}$$

This analysis provides a quantitative characterization of the different reasons that guide the decision in the Won, Lost, and disjunctive conditions The second gamble is accepted in the Won condition because one is guaranteed a net gain, and it is accepted in the Lost condition because the sure loss is more aversive than the mixed prospect The second gamble is not accepted in the disjunctive condition because people do not ask themselves whether they would accept the second gamble in case they won the first gamble and in case they lost Instead, they evaluate the second gamble in isolation and reject it because of loss aversion

The foregoing analysis combines the S-shape value function of prospect theory with the additional assumption that the outcome of the first gamble is incorporated when the decision maker knows that he won or that he lost, but not when he does not know whether he has won or lost Recall that in the modified problem, the first gamble yields a gain of either $300 or $600 Hence, the decision maker can evaluate the second gamble knowing that he or she has won at least $300 According to the value function, the decision maker should now accept the second gamble Indeed, STP was satisfied in the modified problem (For further discussion of situations in which prior outcomes are segregated or aggregated, see Redelmeier & Tversky, 1992, and Thaler & Johnson, 1990)

DISCUSSION

We have attributed the observed violations of STP to a loss of acuity induced by uncertainty about an outcome when the reasons for choice differ depending on that outcome According to this account, violations of STP should be substantially reduced or eliminated when the subjects in the disjunctive condition are given an opportunity to contemplate their own preferences in the Won and in the Lost conditions (Recall that in the original study, we presented subjects with the Won, Lost, and disjunctive versions each a week apart, so that the logical relation among the versions was not transparent) To test this prediction, we presented another group of subjects (N = 87) with all three problems concurrently, the disjunctive version immediately followed the Won and Lost versions on the same page. The percentages of subjects who accepted the second gamble in the Won condition (71%) and in the Lost condition (56%) when the versions were presented concurrently were almost identical to the percentages when the versions were presented a week apart. However, the tendency to accept the second gamble in the disjunctive condition rose from 36% in the original separated presentation to 84% in the concurrent presentation. Furthermore, only 6% of the subjects in the concurrent presentation exhibited the pattern "accept after a win, accept after a loss, but reject when uncertain," compared with 27% in the separated presentation. This result shows that, like other axioms of choice such as substitution and stochastic dominance, STP tends to hold when its application is transparent, even though it is sometimes violated when its application is not obvious (see, e.g., Tversky & Kahneman, 1986). Once subjects realize that they accept the second gamble regardless of the outcome of the first, most are compelled to accept the second gamble in the disjunctive version as well.

Elsewhere (Shafir & Tversky, in press), we describe another example of a disjunction effect in a one-shot prisoner's dilemma game, played on a computer for real payoffs. Subjects ($N = 80$) played a series of prisoner's dilemma games, without feedback, each against a different unknown opponent supposedly selected at random from among the participants. In this setup, the rate of cooperation was 3% when subjects knew that the opponent had defected, and 16% when they knew that the opponent had cooperated. However, when subjects did not know whether their opponent had cooperated or defected (as is normally the case in this game), the rate of cooperation rose to 37%.[1] Contrary to STP, many subjects defected when they knew their opponent's choice—be it cooperation or defection—but cooperated when their opponent's choice was not known. The finding that the rate of cooperation is lower when the opponent cooperates than when the opponent's response is unknown is inconsistent with common explanations of cooperation in terms of social norms and moral imperatives (e.g., do not defect when the other person cooperates). These data suggest that the observed cooperation in one-shot prisoner's dilemma games might be due, in part at least, to a disjunction effect.

One implication of the disjunction effect is that people will sometimes purchase information that has no impact on their actual decision. In the Hawaii problem, for example, subjects were willing, in effect, to pay for information that was not going to change their choice but—as we have interpreted it—merely promised to provide them with clearer reasons for taking the vacation: reward in case of success, consolation in case of failure. In a variation on the aforementioned prisoner's dilemma experiment, subjects were given the opportunity, for a small fee, to learn their opponent's choice before making their own. Recall that the great majority of subjects in this experiment defected, regardless of whether the opponent had decided to cooperate or defect. Nevertheless, on 81% of the trials, subjects paid to discover the decision of their opponent. Although this behavior can be attributed to curiosity, we conjecture that people's willingness to purchase the information would have diminished had they realized that it would not affect their decision.

It appears that people often seek information that reduces uncertainty, even when that information has no impact on subsequent decisions. Baron, Beattie, and Hershey (1988) illustrated this tendency in a hypothetical medical setting where subjects chose to conduct tests that were not going to change the choice of treatment. Indeed, the problem of excessive testing in medicine has been addressed by several authors (see, e.g., Allman, Steinberg, Keruly, & Dans, 1985; Kassirer, 1989). Medical tests that do not alter preferred treatments may nevertheless appear worthwhile if they promise to provide clearer reasons for those treatments, and make it easier for physicians to justify the treatments to themselves, their patients, and the courts.

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REFERENCES

Allman, R.M., Steinberg, E.P., Keruly, J.C., & Dans, P.E. (1985). Physician tolerance for uncertainty: Use of liver-spleen scans to detect metastases. *Journal of the American Medical Association, 254*, 246–248.

Baron, J., Beattie, J., & Hershey, J.C. (1988). Heuristics and biases in diagnostic reasoning: II. Congruence, information, and certainty. *Organizational Behavior and Human Decision Processes, 42*, 88–110.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*, 263–291.

Kassirer, J.P. (1989). Our stubborn quest for diagnostic certainty. *New England Journal of Medicine, 320*, 1489–1491.

Redelmeier, D.A., & Tversky, A. (1992). On the framing of multiple prospects. *Psychological Science, 3*, 191–193.

Savage, L.J. (1954). *The foundations of statistics*. New York: Wiley.

Shafir, E., & Tversky, A. (in press). Thinking through uncertainty: Nonconsequential reasoning and choice. *Cognitive Psychology*.

Thaler, R.H., & Johnson, E.J. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science, 39*, 643–660.

Tversky, A., & Bar-Hillel, M. (1983). Risk: The long and the short. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*, 713–717.

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *The Journal of Business, 59*, S251–S278.

Tversky, A., & Kahneman, D. (in press). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*.

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