Research Article

DECISION AFFECT THEORY: Emotional Reactions to the Outcomes of Risky Options

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Abstract—*How do people feel about the outcomes of risky options? Results from two experiments demonstrate that the emotional reaction to a monetary outcome is not a simple function of the utility of that outcome. Emotional responses also depend on probabilities and unobtained outcomes. Unexpected outcomes have greater emotional impact than expected outcomes. Furthermore, any given outcome is less pleasant if an unobtained outcome is better. We propose an account of emotional experiences associated with outcomes of decisions called decision affect theory. It incorporates utilities, expectations, and counterfactual comparisons into hedonic responses. Finally, we show that choices between risky options can be described as the maximization of expected emotional experiences as predicted by decision affect theory. That is, people choose the risky option for which they expect to feel better on average.*

Most theories of decision making treat choice behavior as a cognitive process; people assess their values, define their goals, and take actions to achieve those goals. But anyone who has ever made an important decision knows that what really happens is not that simple. People often base decisions on emotions.

Emotions influence decisions in two ways. First, emotional states influence decisions, and these effects are well documented (Bower, 1981; Carnevale & Isen, 1986; Isen & Daubman, 1984; Janis & Mann, 1977; Schwarz, 1990; Schwarz, Strack, Kommer, & Wagner, 1987; Wright & Bower, 1992). Second, decisions are influenced by anticipated emotions, those people expect to feel about outcomes of decisions.

Most theories of decision making are silent about the role of emotional states or anticipated emotions. Janis and Mann (1977) discussed the role of emotional states in decision making, although not in a formal way. A few other attempts have been made to incorporate anticipated emotions into decisions. Savage (1951, 1954) proposed a minimax principle that prescribes selecting the option that minimizes one's maximum regret. Although this rule might apply in some contexts, it is unlikely that people would focus solely on the worst outcome to the exclusion of all else.

More recently, Loomes and Sugden (1982) and Bell (1982), respectively, incorporated regret into a theory of choice. According to this theory, people adjust their utilities to incorporate anticipated emotions. Regret theory captures the anticipated emotional reaction to an outcome when one learns that a different choice would have produced a better outcome. In addition to regret, these theorists considered the role of disappointment (Bell, 1985; Loomes & Sugden, 1986). Disappointment theory captures the anticipated emotional reaction to an outcome when one learns that another state of the world would have produced a better outcome. Both regret theory and disappointment theory focus on counterfactual comparisons. Regret arises from comparisons between choices, and disappointment comes from comparisons across states of the world. In these theories, anticipated emotions are never measured directly. Rather, they are postulated and assumed to influence choice.

In this article, we measure emotional experiences associated with the outcomes of risky options represented as gambles with monetary consequences. Subjects played each gamble one at a time and learned its outcome. Then, we elicited their emotional reactions. We focus here on emotional responses in choiceless contexts. In another report, we consider emotions that follow from choices (Mellers, Schwartz, & Ritov, 1997).

DECISION AFFECT THEORY

Emotional experiences are often shaped by counterfactual thinking (Baron, 1994; Kahneman & Miller, 1986; Roese & Olson, 1995). The importance of counterfactual comparisons on hedonic experiences can be illustrated by a story from Kahneman and Tversky (1982): "The winning number in a lottery was 865304. Three individuals compare the ticket they hold to the winning number. John holds 361204, Mary holds 965304, Peter holds 865305" (p. 170). How upset is each of the individuals? Most people agree that Peter is most upset, although all three of them have lost. Identical outcomes can produce very different emotional experiences, depending on one's counterfactual comparisons.

We propose a theory of emotional experiences that we call decision affect theory. Decision affect theory is similar to disappointment theory, although it is a theory of postdecision affect rather than choice. Consider a gamble with two outcomes, a and b. Suppose the gamble is played, and Outcome a occurs. According to decision affect theory, the feeling associated with Outcome a is expressed

$$R_a = a^* [u_a + g(u_a - u_b)^*(1 - s_a)] + b \quad (1)$$

where a and b are linear coefficients in a judgment function relating an emotional feeling to a response, u_a and u_b are the utilities of the obtained and unobtained outcomes, respectively, and s_a is the subjective probability of Outcome a. The g function is called the disappointment function and reflects the comparison between what occurred and what might have occurred under a different state of the world. The function is weighted by $1 - s_a$, the probability that something else would occur.

We report here two experiments in which we tested decision affect theory. We then show how choices can be predicted from emotional experiences.

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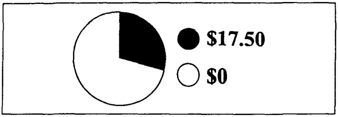

Fig. 1 Example of a gamble display

EXPERIMENT 1

Method

Instructions and stimuli

Subjects were told that the experiment involved risky decisions Participants would earn $5 on average, but there was a small chance that they would win up to $8 or lose up to $6 In the unlikely event that they lost money, they would be required to do menial tasks in the laboratory at a rate of $10 an hour to pay off their debts No one refused to participate

Subjects were presented with gambles one at a time They learned the outcome of each gamble and were informed that all outcomes were real wins or losses They were told that the computer would keep track of the outcomes, and the grand total, displayed at the end of the experiment, would determine their final payment Because there were too many trials for subjects to keep track of their grand totals, they were all paid $6 No subject appeared to notice or complained about a discrepancy between the final payment and actual total

Gambles were displayed as pie charts on IBM personal compu rs as shown in Figure 1 Each region of the pie chart represented he chance of receiving the outcome associated with that region Aft a brief display, a pointer appeared in the center of the gamble he pointer made several rotations and eventually stopped The sub ct then rated his or her feelings about the outcome on a rating sc le ranging from 50 (*extremely elated*) to −50 (*extremely disappoint l*)

Design

Twenty-five gambles were constructed from a probability-by-gain factorial design, with probabilities of 09, 17, 29, 52, and 94 and gains of $5 40, $9 70, $17 50, $31 50, and $56 70 The other outcome was always zero Another 25 gambles in which gains were converted to losses were also used The two sets were mixed together and presented in a random order Each gamble was presented twice to obtain the emotional response to each outcome All gambles were presented once before any gamble was repeated

Participants

Sixty-seven undergraduates at the University of California, Berkeley, recruited from advertisements around campus, served as subjects Thirty-nine were females, and 28 were males They ranged in age from 18 to 26

Results

Figure 2 presents mean emotional responses against obtained wins and losses when the unobtained outcome was zero Separate curves are shown for each probability of the obtained outcome Solid lines

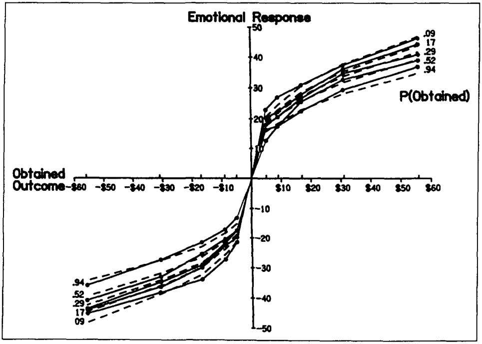

Fig. 2. Emotional responses to gains and losses from Experiment 1 plotted against obtained outcomes with a separate curve for each probability of the obtained outcome Unobtained outcomes were always zero The spacing between the curves shows the effect of surprise Dashed lines are predictions of decision affect theory

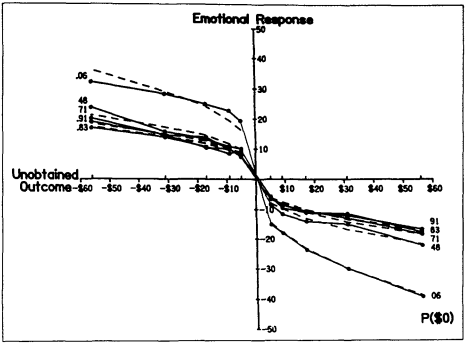

Fig. 3 Emotional responses to the outcome of $0 from Experiment 1 plotted against unobtained outcomes with a separate curve for each probability of the $0 outcome Slopes of the curves show disappointment effects, and spacings between the curves show surprise effects Dashed curves are predictions of decision affect theory

are data, and dashed lines are predictions of decision affect theory (discussed later) Not surprisingly, the subjects were elated with wins and disappointed with losses

Effects of surprise

Figure 2 shows that emotional experiences also depend on the probability of the obtained outcome Surprising wins are more elating than expected wins, and surprising losses are more disappointing than expected losses For example, when people won $56 70 and the probability of winning was large (94), they were elated, the average emotional response was 36 But when people won $56 70 and the probability of winning was small (09), they were even more elated, the average response to the same win was 46 Similarly, when people lost $56 70 and the probability of losing was large, they were disappointed But when the probability was small, they were even more disappointed Average responses were –35 and –45, respectively [1]

The effects of surprise are strong enough to make smaller wins more pleasurable than larger wins For example, an expected win of $9 70 was less elating than a smaller, unexpected win of $5 40 Similarly, an expected loss of $31 50 was less disappointing than a smaller, unexpected loss of $17 50 The majority of individual subjects showed these patterns

Effects of disappointment

Figure 3 presents emotional responses to outcomes of $0, every point is a different reaction to the same outcome Results are plotted against unobtained outcomes with separate curves for each probability of the $0 outcome Solid lines on the left show positive feelings when subjects avoided a loss, and solid lines on the right show negative feelings when subjects missed an opportunity to win Dashed lines are predictions The slopes of the curves show effects of counterfactual comparisons Feelings about the same outcome differed greatly depending on what else could have occurred When people avoided a loss of $56 70, they were elated to get nothing, but when they missed an opportunity to win $56 70, they were disappointed with that same outcome

Unobtained outcomes serve as reference points for evaluating obtained outcomes Holding all else constant, people feel worse about an outcome when the counterfactual outcome is better We call this result the disappointment effect Slopes of the curves in Figure 3 show that disappointment increases with the difference between obtained and unobtained outcomes Moreover, disappointment is magnified by the surprisingness of the outcome People felt worse about the outcome of $0 when they were expecting a large win than if the win was unlikely Conversely, people felt better about the outcome of $0 when they were expecting a large loss than if loss was unlikely

Do these effects also occur when people balance positive feelings about wins against negative feelings about losses? Experiment 2 answers this question

EXPERIMENT 2

Method

This experiment had two tasks, an emotions task similar to that described in Experiment 1 and a choice task in which subjects selected the gamble they preferred from a pair of gambles

1 All comparisons between means were statistically significant with an alpha level of 5%

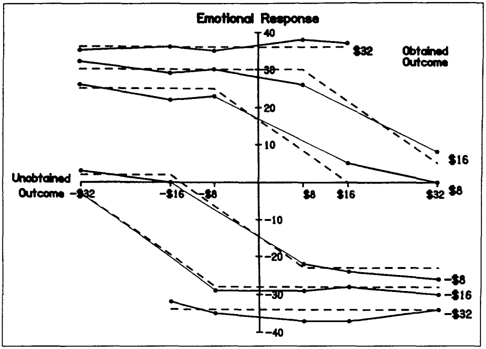

Fig 4 Emotional responses from Experiment 2 plotted against unobtained outcomes with a separate curve for each obtained outcome, when the probability of the obtained outcome was 5 Dashed curves are predictions of decision affect theory

Instructions

Subjects were told that their payments would be based on both tasks In the emotions task, they were shown the outcome of each gamble and were told that the computer kept a running total of the outcomes In the choice task, subjects were not shown the outcomes of the gambles, they were told that the computer would determine the outcomes of chosen gambles and keep a running total If the subject was indifferent, the computer would randomly select a gamble The sum of the totals from the two tasks would be the subject's final payment Before the experiment began, subjects were told that people earned $10 on average for the two tasks, but there was a small chance they would win as much as $15 or lose as much as $8 No one refused to participate, and all subjects were paid $12

Instructions in the emotions task were identical to those in Experiment 1 In the choice task, subjects were told to choose the gamble they preferred to play by pressing one of three computer keys To play the left or the right gamble, they pressed a key on the left or the right, respectively If they were indifferent, they pressed a key in the middle Subjects performed the tasks approximately 3 days apart, and task order was counterbalanced

Design

Forty-five two-outcome gambles were constructed from a gamble-by-probability factorial design Gambles had two outcomes from the set -$32, -$16, -$8, $8, $16, and $32, and the probabilities of Outcome 1 were 2, 5, and 8 Only gambles for which Outcome 1 was better than Outcome 2 were included Two sets of three-outcome gambles were also used In one set, Outcome 1 was $20, Outcome 2 was $4 or $40, and Outcome 3 was -$8, $8, $16, or $32 Probabilities of Outcomes 1, 2, and 3 were 1, 4, and 5 respectively In the other set, the signs of the outcomes were reversed There were 16 three-outcome gambles

In the emotions task, subjects were presented with each two-outcome gamble twice and each three-outcome gamble three times The pointer stopped at a different outcome each time In the choice task, subjects were presented with all nondominated pairs of two-outcome gambles Results from the choice task are presented in the General Discussion

Participants

Forty-seven subjects, recruited in the same way as those in Experiment 1, performed the two tasks There were 35 females and 12 males Their ages ranged from 18 to 27

Results

Figure 4 presents emotional responses to gambles when neither the obtained nor the unobtained outcome was zero Curves represent different obtained outcomes, unobtained outcomes are on the abscissa The probability of the obtained outcome is 5 This figure shows the simultaneous effects of both outcomes, the spacings between the curves represent the effect of obtained outcomes, and the changes in the slopes of the curves show the effect of unobtained outcomes People were less sensitive to the magnitude of the difference between obtained and unobtained outcomes with these gambles than with those in Experiment 1 Instead, they felt simply elated if their outcome was the better of the two and disappointed if it was the worse [2]

2 The continuous disappointment effects in Figure 3 and the dichotomous effects in Figure 4 could arise if people place greater attention on the unobtained outcome when they receive $0 than when they receive a nonzero outcome

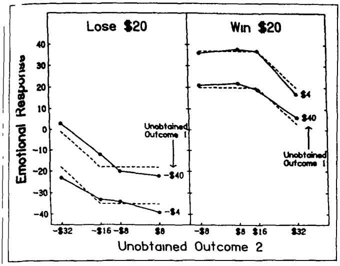

Fig 5 Emotional responses to wins of $20 (upper curves) and losses of $20 (lower curves) in gambles with three outcomes from Experiment 2 Each curve represents one of the two unobtained outcomes, the other is plotted on the abscissa Dashed curves are predictions of decision affect theory

With obtained outcome held constant, differences between feelings when the obtained outcome was the better or the worse are quite large For example, emotional reactions to wins of $8 varied from 26 to 0 when unobtained outcomes were −$32 and $32, respectively Likewise, emotional responses to losses of $8 varied from 3 to −26 as the unobtained outcome varied from −$32 to $32 Gains can be disappointing, and losses can be elating Furthermore, winning can feel worse than losing, depending on the counterfactual comparison Similar results were found by Boles and Messick (1995)

Gambles with two nonzero outcomes also show surprise effects The pleasure associated with winning $32 and avoiding a loss of $32 increased with the surprisingness of the win When the probability of winning $32 was 8, 5 and 2, mean responses to a $32 win were 32, 35, and 38, respectively Likewise, the displeasure associated with losing $32 and missing a chance to win $32 increased with the surprisingness of the loss When the probability of losing was 8, 5, and 2, mean responses to a $32 loss were −31, −34, and −40, respectively In sum, there are effects of surprise and disappointment when people balance positive feelings against negative feelings

Figure 5 shows emotional reactions to the three-outcome gambles The lower curves present emotional responses to losses of $20, and the upper curves show reactions to wins of $20 Feelings are plotted against one unobtained outcome with a separate curve for the other The slopes of the curves and the spacing between the curves demonstrate the simultaneous effects of both unobtained outcomes Pleasure increases as each of the two unobtained outcomes decreases For example, when people lost $20, they felt very unhappy if they could have lost only $4 or $8, moderately unhappy if they could have lost $4 or $32, and mildly happy if they could have lost $40 or $32

FIT OF THE THEORY

We fit decision affect theory to data in both experiments by means of FORTRAN programs that used Chandler's (1969) STEPIT subroutine to obtain least squares parameter estimates The theory was represented as a prediction equation with a set of unknown parameters We selected a set of starting parameters that were iteratively adjusted to minimize the proportion of residual variance (i e , the sum of squared errors between mean responses and predictions relative to the sum of squares in the means)

To fit decision affect theory in Experiment 1, we assumed that g was a power function that could differ for positive and negative differences [3] We selected a power function because of the continuous effects of the counterfactual comparisons shown in Figure 3 These assumptions required 20 parameters (eight utilities, eight subjective probabilities, two coefficients in the linear response function, and two exponents in g) to describe the 100 data points [4] The theory provided an excellent account of the data the proportion of residual variance was less than 1% Predictions are shown as dashed lines in Figures 2 and 3, deviations are small and generally nonsystematic Estimated utilities were concave downward for gains and concave upward for losses Estimated probabilities had a sigmoidal shape, small probabilities were overweighted, and large probabilities were underweighted [5]

We also predicted emotional responses from decision affect theory in Experiment 2, but this time, we assumed that g was a step function that could have asymmetric steps about zero For two-outcome gambles, we used Equation 1, and for three-outcome gambles, we applied the disappointment function to the difference between the utility of the obtained outcome and the utility of the unobtained outcomes for each unobtained outcome Both terms were weighted by the subjective probability that the obtained outcome would not occur [6] We used 20 parameters (ten utilities, four subjective probabilities, two estimated steps in the step function for two-outcome gambles, two estimated steps for three-outcome gambles, and two linear coefficients in the response function) to describe the 156 data points [7] Once again, the theory gave an excellent account of the data, leaving less than 1% residual variance in the mean responses Predictions are shown in Figures 4 and 5, and deviations are small Estimated utilities were fairly linear, with slight concavity in the gain domain and slight convexity in the loss domain Estimated probabilities were sigmoidal, that is, smaller probabilities were overestimated, and larger probabilities were underestimated [8] Estimated steps in the disappointment function

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3 The disappointment function $g(x)$ was expressed as x^{kp} and $-|x|^{kn}$ for positive and negative values of x respectively where kp and kn are exponents in the power functions

4 We fixed the utilities of $0 $56 70 and −$56 70 and the subjective probabilities of 48 and 52 to their objective values with no loss of generality

5 Estimated utilities were −$46 84, −$39 82 −$32 65, −$27 63 $26 28, $30 67 $37 93, and $46 28 for amounts of −$31 50 −$17 50 −$9 70, −$5 40 $5 40, $9 70 $17 50 and $31 50, respectively Estimated probabilities were 10 32 40, 45 55 58 59 and 64 for probabilities of 06, 09, 17, 29, 71 83, 91 and 94 respectively The exponent in the power function was 1 16 for positive differences and 1 20 for negative differences Finally the intercept and multiplier in the judgment function were 1 14 and 0 35 respectively

6 This representation is insensitive to the separate probabilities of the unobtained outcomes If an unobtained outcome was very unlikely, that unobtained outcome might have very little effect For this reason our representation might require generalization in other contexts

7 We fixed the utility of $32 to 32 and −$32 to −32 and the probability of 5 to 5

8 Estimated utilities were −$40 91 −$26 86 −$22 42, −$16 23, −$7 55, $10 80, $16 54 $23 50 $27 65, and $42 75 for amounts of −$40, −$20 −$16, −$8, −$4, $4 $8, $16, $20 and $40, respectively Estimated probabilities were

were 29 and −41 for two-outcome gambles and 8 and −15 for three-outcome gambles That is, the effect of disappointment was larger than that of elation, receiving the worse outcome had greater impact than receiving the better outcome In sum, decision affect theory gave an excellent account of the emotional experience associated with the outcome of a gamble

GENERAL DISCUSSION

How are decisions related to emotions? One hypothesis, not too dissimilar from Savage's minimax principle, is that people select the gamble that minimizes negative affect That is, they avoid the option that could make them feel the worst To test this hypothesis, we examined predicted feelings based on decision affect theory for the less pleasant outcome for each gamble in a pair in Experiment 2 We assumed that people avoided the gamble with the stronger possible negative affect The correlation between binary predictions and binary choices was only 20 Choices were not predictable from this simple strategy of minimizing unpleasant experiences

Suppose that people imagined their feelings about each of the two possible outcomes in a gamble, then weighted those anticipated feelings by their subjective beliefs they would occur Consider a gamble with Outcomes a and b We define the subjective expected emotion associated with the gamble as

$$s_a{*}R_a + s_b{*}R_b$$

where s_a and s_b are the subjective probabilities of Outcomes a and b occurring, and R_a and R_b are the predicted feelings associated with these outcomes, as described by decision affect theory The subjective expected emotion represents the pleasure associated with the gamble on average

We computed the subjective expected emotion for each gamble in every pair in Experiment 2 based on the predicted emotions and subjective probabilities from decision affect theory We then assumed that people selected the gamble with the higher subjective expected emotion The correlation between binary choices and binary predictions was 89[1] Choices are closely related to the strategy of selecting the gamble with the better expected feeling

Is maximizing subjective expected emotions different from maximizing subjective expected utilities? Utilities are typically assumed to be independent of beliefs, but emotional responses vary with beliefs and expectations Utilities are typically assumed to be a monotonic function of monetary outcomes, but hedonic experiences can be nonmonotonic over outcomes Smaller wins can be more pleasurable than larger wins, depending on one's expectations and counterfactual comparisons Furthermore, the same monetary outcome can produce many different hedonic experiences It may seem surprising, but these two strategies can lead to similar choices, and under special cases, they are identical

Consider the expression for decision affect theory (Equation 1)

[1] 00 33 49 and 64 for probabilities of 1 2, 4 and 8, respectively Estimated steps for elation and disappointment were 29 and −41 for two-outcome gambles and 8 and −15 for three-outcome gambles The intercept and multiplier in the judgment function were 0 72 and 0 71 respectively

The subjective expected pleasure of the gamble becomes

$$s_a{*}\ \{a{*}[u_a + g(u_a - u_b){*}(1 - s_a)] + b\} + (1 - s_a){*}\ \{a{*}[u_b + g(u_b - u_a){*}s_a] + b\},$$

which can be rewritten as

$$a{*}[s_a{*}u_a + (1 - s_a){*}u_b + g(u_a - u_b){*}(1 - s_a){*}\ s_a + g(u_b - u_a){*}(1 - s_a){*}s_a] + b$$

If g, the disappointment function, is symmetric about zero, this expression becomes

$$a{*}[s_a{*}u_a + (1 - s_a){*}u_b + g(u_a - u_b){*}(1 - s_a){*}s_a - g(u_a - u_b){*}(1 - s_a){*}s_a] + b,$$

which reduces to

$$a{*}[s_a{*}u_a + (1 - s_a){*}u_b] + b,$$

and this expression is linearly related to the subjective expected utility of the gamble with additive probabilities

To what extent were these two assumptions satisfied in the data? The first assumption of a linear response function was met, but the second assumption of symmetric step sizes in the disappointment function was violated Disappointment was greater in magnitude than elation It is interesting to note that Loomes and Sugden (1986) proposed that the disappointment function was nonlinear, but symmetric Bell (1985) assumed that the disappointment function was linear, but kinked, with steeper slopes for negative differences than positive differences

Do subjective expected emotions predict choices over and beyond subjective expected utilities? The correlation between binary choices and subjective expected emotions with subjective expected utilities partialed out was 26 With these gambles, there was some additional predictability, but the overlap was substantial Perhaps in other cases, the strategies can be distinguished

In conclusion, emotional experiences associated with the outcomes of decisions differ greatly from the utilities of those outcomes Emotional experiences are enhanced by surprise, and the same outcome can feel very pleasant or very unpleasant, depending on the counterfactual comparisons Despite these differences, maximizing expected pleasure is similar, although not identical, to maximizing expected utility These two strategies, subjective expected emotions and subjective expected utilities, can lead to similar choices for different reasons

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