Research Report

Investment Behavior and the Negative Side of Emotion

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ABSTRACT—***Can dysfunction in neural systems subserving emotion lead, under certain circumstances, to more advantageous decisions? To answer this question, we investigated how normal participants, patients with stable focal lesions in brain regions related to emotion (target patients), and patients with stable focal lesions in brain regions unrelated to emotion (control patients) made 20 rounds of investment decisions. Target patients made more advantageous decisions and ultimately earned more money from their investments than the normal participants and control patients. When normal participants and control patients either won or lost money on an investment round, they adopted a conservative strategy and became more reluctant to invest on the subsequent round; these results suggest that they were more affected than target patients by the outcomes of decisions made in the previous rounds.***

In contrast to the historically dominant view of emotions as a negative influence in human behavior (Peters & Slovic, 2000), recent research in neuroscience and psychology has highlighted the positive roles played by emotions in decision making (Bechara, Damasio, Tranel, & Damasio, 1997; Damasio, 1994; Davidson, Jackson, & Kalin, 2000; Dolan, 2002; LeDoux, 1996; Loewenstein & Lerner, 2003; Peters & Slovic, 2000; Rahman, Sahakian, Rudolph, Rogers, & Robbins, 2001). Notwithstanding the fact that strong negative emotions such as jealousy and anger can lead to destructive patterns of behavior such as crimes of passion and road rage (Loewenstein, 1996), in a series of studies using a gambling task, researchers have shown that individuals with emotional dysfunction tend to perform poorly compared with those who have intact emotional processes (Bechara et al., 1997; Damasio, 1994; Rogers et al., 1999). However, there are reasons to think that individuals deprived of normal emotional reactions might actually make better decisions than normal individuals (Damasio, 1994). For example, consider the case of a patient with ventromedial prefrontal damage who was driving under hazardous road conditions (Damasio, 1994). When other drivers reached an icy patch, they hit their brakes in panic, causing their vehicles to skid out of control, but the patient crossed the icy patch unperturbed, gently pulling away from a tailspin and driving ahead safely. The patient remembered the fact that not hitting the brakes was the appropriate behavior, and his lack of fear allowed him to perform optimally. A broad thrust of the current research is to delve into this latter possibility, that individuals deprived of normal emotional reactions might, in certain situations, make more advantageous decisions than those not deprived of such reactions.

Recent evidence suggests that even relatively mild negative emotions that do not result in a loss of self-control can play a counterproductive role among normal individuals in some situations (Benartzi & Thaler, 1995). When gambles that involve some possible loss are presented one at a time, most people display extreme levels of risk aversion toward the gambles, a condition known as *myopic loss aversion* (Benartzi & Thaler, 1995). For example, most people will not voluntarily accept a 50–50 chance to gain $200 or lose $150, despite the gamble's high expected return. Myopic loss aversion has been advanced as an explanation for the large number of individuals who prefer to invest in bonds, even though stocks have historically provided a much higher rate of return, a pattern that economists refer to as the *equity premium puzzle* (Narayana, 1996; Siegel & Thaler, 1997).

On the basis of research showing that patients with neurological disease that impairs their emotional responses take risks even when they result in catastrophic losses (Bechara et al., 1997), as well as anecdotal evidence that such patients may, under certain circumstances, behave more efficiently than normal subjects (Damasio, 1994), we hypothesized that these same patients would make more advantageous decisions than normal subjects (or than patients with neurological lesions that do not impair their emotional responses) when faced with the types of positive-expected-value gambles we have just highlighted. In

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other words, if myopic loss aversion does indeed have an emotional basis as suggested in the literature (Loewenstein, Weber, Hsee, & Welch, 2001), then any dysfunction in neural systems subserving emotion ought to result in reduced levels of risk aversion and, thus, lead to more advantageous decisions in cases in which risk taking is rewarded.

To test our hypothesis, we developed a risky decision-making task that simulated real-life investment decisions in terms of uncertainties, rewards, and punishments. The task, closely modeled on a paradigm developed by Gneezy (1997) to demonstrate myopic loss aversion, was designed so that it would behoove participants to invest in every round because the expected value on each round was higher if one invested than if one did not. Our goal, then, was to demonstrate that an individual with a deficient emotional circuitry would experience less myopic loss aversion and make more advantageous decisions than an individual with an intact emotional circuitry. Such a finding would provide a new source of support for the idea that emotions play an important role in risk taking and risk aversion.

METHOD

Participants

We studied 19 normal participants and 15 target patients with chronic and stable focal lesions in specific components of a neural circuitry that has been shown to be critical for the processing of emotions (Damasio, 1994; Davidson et al., 2000; Dolan, 2002; LeDoux, 1996; Rahman et al., 2001; Sanfey, Hastie, Colvin, & Grafman, 2003). Specifically, the target patients' lesions were in the amygdala (bilaterally; 3 patients), the orbitofrontal cortex (bilaterally; 8 patients), or the right insular or somatosensory cortex (4 patients). We also studied 7 control patients with chronic and stable focal lesions in areas of the brain that are not involved in emotion processing. All these patients had a lesion in the right (4 patients) or left (3 patients) dorsolateral sector of the prefrontal cortex.

The patients were drawn from the Division of Cognitive Neuroscience's Patient Registry at the University of Iowa and have been described previously (Bechara et al., 1997). The lesions in the prefrontal cortex are due to stroke or surgical removal of a meningioma, those in the right insular or somatosensory region are due to stroke, and those in the amygdala are due to herpes simplex encephalitis (2 patients) or Urbach Weithe disease (1 patient). (The patients with bilateral amygdala damage due to herpes simplex encephalitis also have damage to the hippocampal system, and consequently have severe anterograde memory impairment. However, they have normal IQ and intellect. Removing the data for these patients did not affect the results.) The control patients' lesions in the dorsolateral sector of the prefrontal cortex are due to stroke.

All target patients have been shown to perform poorly on the Iowa Gambling Task (Bechara, Damasio, & Damasio, 2003) and to have low emotional intelligence as measured by the EQi (Bar-On, Tranel, Denburg, & Bechara, 2003). All control patients have been shown to perform advantageously on the Iowa Gambling Task and to have normal EQi scores (Bar-On et al., 2003; Bechara et al., 2003). The target and control patients had a mean age of 53.6 (SD = 11) at the time of this study; they had 14.5 years of education on average (SD = 3) and mean verbal and performance IQs of 107.2 (SD = 11.5) and 103.4 (SD = 14.5), respectively.

The normal participants were recruited from the local community through advertisement in local newspapers. None had any history of neurological or psychiatric disease (assessed by questionnaire). Their mean age was 51.6 years (SD = 13); on average, they had 14.6 (SD = 3) years of education and verbal and performance IQs of 105.5 (SD = 7) and 101.4 (SD = 10), respectively.

All participants provided informed consent that was approved by the appropriate human subject committees at the University of Iowa.

Procedure

At the beginning of the task, all participants were endowed with $20 of play money, which they were told to treat as real because they would receive a gift certificate for the amount they were left with at the end of the study. Participants were told that they would be making several rounds of investment decisions and that, in each round, they had to decide between two options: invest $1 or not invest. On each round, if the participant decided not to invest, he or she would keep the dollar, and the task would advance to the next round. If the participant decided to invest, he or she would hand over a dollar bill to the experimenter. The experimenter would then toss a coin in plain view. If the outcome of the toss were heads (50% chance), then the participant would lose the $1 that was invested; if the outcome of the toss were tails (50% chance), then $2.50 would be added to the participant's account. The task would then advance to the next round.

The task consisted of 20 rounds of investment decisions, and the three groups of participants took roughly the same time on the task. Note that, as indicated earlier, the design of this investment task is such that it would behoove participants to invest in all the rounds because the expected value on each round is higher if one invests ($1.25) than if one does not ($1). In fact, if one invests on each and every round, there is only around a 13% chance of obtaining lower total earnings than if one does not invest in every round and simply keeps the $20.

RESULTS AND DISCUSSION

Overall Investment Decisions and Amounts Earned

Examination of the percentage of the 20 rounds in which participants decided to invest revealed that the target patients made decisions that were closer to a profit-maximizing view-

TABLE 1

Percentages of Decisions to Invest as a Function of Decision and Outcome in the Previous Round

	Target patients					
Previous round	Orbitofrontal lesion ($n = 8$)	Insular, somatosensory lesion ($n = 4$)	Amygdala lesion ($n = 3$)	Overall	Normal participants	Control patients
Did not invest	70.4	70.0	83.3	74.2	64.4	63.4
Invested and lost	79.8	96.8	84.3	85.2	40.5	37.1
Invested and won	79.1	94.4	83.3	84.0	61.7	75.0
Invested overall	79.4	91.3	85.0	83.7	57.6	60.7

point than the other participants did (see Table 1). Specifically, target patients invested in 83.7% of the rounds on average, whereas normal participants invested in 57.6% of the rounds (Wilcoxon statistic = 345.0, $p < .002$) and control patients invested in 60.7% of the rounds (Wilcoxon two-sample test statistic = 44.5, $p < .006$). Further, as hypothesized, target patients earned more money over the 20 rounds of the experiment ($25.70, on average) than did normal participants ($22.80; Wilcoxon statistic = 315.5, $p < .03$) or control patients ($20.07; Wilcoxon statistic = 44, $p < .006$); the average amount earned by normal participants did not differ from that earned by control patients (Wilcoxon statistic = 73, n.s.).

Figure 1 shows the percentage of rounds in which participants decided to invest, broken down into four 5-round blocks. The pattern of results suggests that all three groups of participants started close to the normative benchmark. However, unlike target patients, who remained close to the normative benchmark, normal participants and control patients seemed to become more conservative, investing in fewer rounds, as the investment task progressed. One potential account for these findings is that emotional reactions to the outcomes on preceding rounds affected decisions on subsequent rounds for normal participants and control patients, but not for target patients. We examine this potential account in greater detail in the next section.

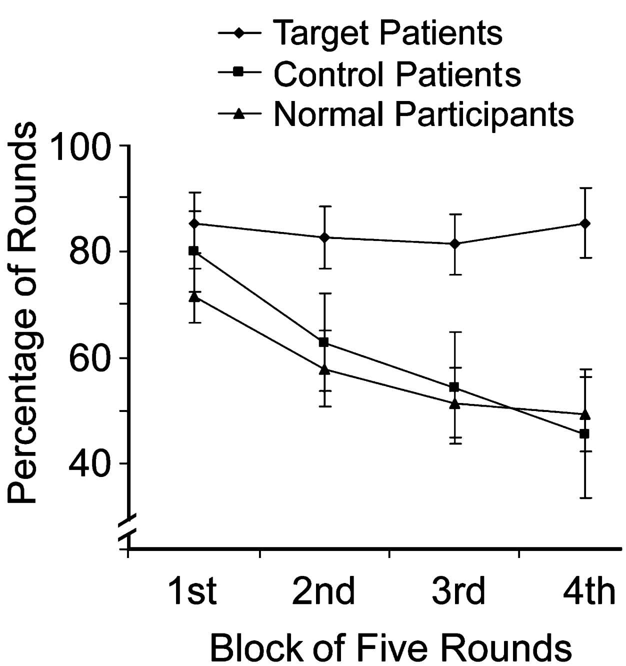

Fig. 1. Percentage of rounds in which participants decided to invest $1.

Impact of Outcomes on Previous Rounds on Decisions in Subsequent Rounds

We conducted a lagged logistic regression analysis to examine whether the decision-outcome combination in preceding rounds (did not invest, invested and won, invested and lost) affected decisions on successive rounds more for control participants (normal participants and control patients) than for target patients. The dependent variable in this analysis was whether the *decision* on a particular round was to invest (coded as 1) or not invest (coded as 0). The independent variables were several dummies that were created for the analysis: *control* (coded as 1 for control participants, 0 otherwise), *invest-won* (coded as 1 if the participant invested on the previous round and won, 0 otherwise), *invest-lost* (coded as 1 if the participant invested on the previous round and lost, 0 otherwise), and participant-specific dummies (e.g., *dummy1*, coded as 1 for Participant 1, 0 otherwise). The overall logit model that was tested was *decision = control invest-won invest-lost control by invest-won control by invest-lost dummy1 dummy2 etc*. Note that any significant interactions would indicate that the effects of the decisions and outcomes in preceding rounds on decisions made in successive rounds were different for target patients and control participants.

Both interactions in the logit model were significant: *control by invest-won*, $\chi^2(1) = 10.27$, $p < .001$; *control by invest-lost*, $\chi^2(1) = 31.98$, $p < .0001$. These results suggest that normal participants and control patients behaved differently from target patients both when they had won on the previous round and when they had lost. As detailed in Table 1, control participants were more likely than target patients to withdraw from risk taking both when they lost on the previous round and when they won. Compared with the target patients, who invested in 85.2% of rounds following losses, normal participants invested in only 40.5% of rounds following losses (Wilcoxon statistic = 350.0, $p < .001$), and control patients invested in only 37.1% of such rounds (Wilcoxon statistic = 45, $p < .006$). Similarly, although target patients invested in 84.0% of rounds following wins, normal participants invested in only 61.7% of rounds following wins (Wilcoxon statistic = 323, $p < .01$), and control patients invested in 75.0% of such rounds (Wilcoxon statistic = 67.5, $p = .16$). These results also suggest that normal participants and control patients were considerably less risk aversive following wins than following losses (normal participants: 61.7% vs. 40.5%, difference = 21.2%; control patients: 75.0% vs. 37.1%, difference = 37.9%); in contrast, target patients invested equally often following wins and following losses (84.0% vs. 85.2%, difference = 1.2%).

CONCLUSIONS

The results of this study support our hypothesis that patients with lesions in specific components of a neural circuitry critical for the processing of emotions will make more advantageous decisions than normal subjects when faced with the types of positive-expected-value gambles that most people routinely shun. Such findings lend support to theoretical accounts of risk-taking behavior that posit a central role for emotions (Loewenstein et al., 2001). Most theoretical models of risk taking assume that risky decision making is largely a cognitive process of integrating the desirability of different possible outcomes with their probabilities. However, researchers have recently argued that emotions play a central role in decision making under risk (Mellers, Schwartz, & Ritov, 1999; Slovic, Finucane, Peters, & MacGregor, 2002). The finding that lack of emotional reactions may lead to more advantageous decisions in certain situations lends further support to such accounts.

Our results raise several issues related to the role of emotions in decision making involving risk. It is apparent that neural systems that subserve human emotions have evolved for survival purposes. The automatic emotions triggered by a given situation help the normal decision-making process by narrowing down the options for action, either by discarding those that are dangerous or by endorsing those that are advantageous. Emotions serve an adaptive role in speeding up the decision-making process. However, there are circumstances in which a naturally occurring emotional response must be inhibited, so that a deliberate and potentially wiser decision can be made. The current study demonstrates this "dark side" of emotions in decision making. Depending on the circumstances, moods and emotions can play useful as well as disruptive roles in decision making. It is important to note that previous experiments demonstrating a positive role of emotion in decision making involved tasks in which decisions were made under ambiguity (i.e., the outcomes were unknown; Bechara et al., 1997). In the present experiment, the patients made decisions under uncertainty (i.e., the outcome involved risk but was defined by some probability distribution). We do not know at this point whether decisions under uncertainty and decisions under ambiguity draw upon different neural processes, so that emotion is disruptive in one case but not the other. Regardless, the issue is not simply whether emotions can be trusted as leading to good or bad decisions. Rather, research needs to determine the circumstances in which emotions can be useful or disruptive, and then the reasoned coupling of circumstances and emotions can be a guide to human behavior.

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