Investment Behavior and the Dark Side of Emotion

Baba Shiv (University of Iowa)

George Loewenstein (Carnegie Mellon University)

Antoine Bechara (University of Iowa)

Hanna Damasio (University of Iowa)

Antonio R. Damasio (University of Iowa)

Can dysfunction in neural systems subserving emotion lead, under certain circumstances, to more advantageous decisions? To answer this question, normal participants, patients with stable focal lesion in varied regions unrelated to emotion (patient-controls), and patients with stable focal lesion in varied regions related to emotion (target patients) made 20 rounds of investment decisions. In contrast to the normal participants and patient-controls, target patients made more advantageous decisions and ultimately earned more money from their investments. Analyses revealed that normal participants and patient-controls were more affected than target patients by the outcomes of decisions made in the previous rounds. When normal subjects and patient-controls either won or lost money on a round, they became more conservative and decided not to invest on the subsequent round. These results support the hypothesis that emotional responses to the outcome of a decision play an important role in risk-taking behavior.

In contrast to the historically dominant view of emotions as a negative force in human behavior, recent research in psychology and neuroscience (*1-6*) has highlighted the positive roles played by emotions in decision-making (*2, 7*). In a series of studies using a gambling task, researchers have shown that individuals with emotional dysfunction tend to perform poorly compared to those with intact emotional processes (*2, 7, 8*). On the other hand, there is little question that emotion can influence decisions negatively. In addition to the obvious 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 (*9*), there are observations suggesting that, in certain tasks, patients deprived of normal emotional reactions actually make better decisions than normal individuals (*10*).

Recent evidence also suggests that even relatively mild negative emotions that do not result in a loss of self-control can play a counterproductive role in some situations (*11*). Most people display extreme levels of risk aversion toward gambles that involve some risk of loss, if the gambles are presented one-at-a-time, a condition known as "myopic loss aversion" (*11*). 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" (*12-14*).

Based on research showing that patients with neurological disease that impairs their emotional responses take risks even when they result in catastrophic losses (*7*), and on clinical observations that such patients may, under certain circumstances, behave more efficiently than normal subjects (*10*), we hypothesized that such patients would make more advantageous decisions than normal subjects and patients with neurological disease that does not impair their emotional responses when faced with the types of positive expected value gambles that most people routinely shun.

To simulate real-life investment decisions in terms of uncertainties, rewards, and punishments, we developed a “risky decision-making task” closely modeled on a paradigm developed in previous research to demonstrate myopic loss aversion (*15*). We studied 15 normal participants, 15 target patients (*16, 17*) with focal lesions in specific components of a neural circuitry that includes the amygdala, orbitofrontal, and insular/somatosensory (SII and SI) cortex, which have been shown to be critical for the processing of emotions (*2*-*6*), and 7 patient-control subjects with focal lesions in areas of the brain that are not part of a neural circuitry that is associated with emotions. We endowed each participant 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 make a decision between two options: invest $1 or not invest. If the decision were <u>not to invest</u>, the task would advance to the next round. If the decision were <u>to invest</u>, they would hand over a dollar bill to the experimenter. The experimenter would then toss a coin in plain view of the subject. If the outcome of the toss was heads (50% chance), they would lose the $1 that was invested; if the outcome of the toss was tails (50% chance), $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. We designed the investment task so that it would behoove participants to invest in all the 20 rounds because the expected value on each round is higher if one invests ($1.25) than if one does not ($1).

Examination of the proportion of rounds in which participants decided to invest reveals that the target patients made decisions that were closer to a profit-maximizing viewpoint. Compared to normal participants who invested in 62.7% of the rounds, and patient-controls who invested in 60.7% of the rounds, on average, patients invested in 83.7% of the rounds (*18*). As a result, target patients earned more money over the 20 rounds of the experiment ($25.70, on average) than did normal participants ($23.40, on average) or patient-controls ($20.07, on average) (*19*).

A lagged logistic regression analysis was carried out (*20*) to delve into potential differences between normal participants, patient-controls, and target patients in the way they made decisions in the investment task. The goal of the analysis was to examine whether the decision/outcome combination in preceding rounds (did not invest, invested and won, invested and lost) affected decisions made on successive rounds differently for normal participants and patient-controls compared to the target patients. The logistic regression yielded significant interactions (*21*), which indicate that normals and patient-controls behaved differently from target patients both when they had won on the previous round, and when they had lost. As detailed in table 1, which examines the proportions of normals, patient-controls and target patients who invested as a function of the decision/outcome on the previous round, normals and patient-controls were more likely to withdraw from risk-taking *both* when they lost on the previous round *and* when they won. Compared to the target patients who invested in 85.2% of rounds following losses on previous rounds, normal participants invested in only 46.9% of rounds, and patient-controls invested in only 37.1% of rounds following such losses (*22*). Similarly, compared to target patients who invested in 84% of rounds following wins on previous rounds, normal participants invested in only 61.4% of rounds, and patient-controls invested in 75% of rounds following such wins (*23*). These results suggest that normal participants and patient-controls were likely to avoid risk (be more conservative) regardless of winning or loosing in the previous round. Further, the results suggest that normal participants and patient-controls were considerably less risk aversive following wins than following losses (normals: 61.4% vs. 46.9%, a difference of 14.9%; patient-controls: 75% vs. 37.1%, a difference of 37.9%) compared to target patients (85.2% vs. 84%, a difference of only 1.2%).

These results support our hypothesis that patients with lesions in specific components of a neural circuitry critical for the processing of emotions would 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. 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, recent treatments have argued that emotions, and particularly feelings of fear, play a central role in decision-making under risk (*24*). The finding that lack of emotional reactions may lead to more advantageous decisions in certain situations lends further support to such accounts.

One issue that arises from our findings is whether normal participants and patient-controls would have performed closer to optimum (i.e., investing in more rounds) as target patients seemed to do if the number of rounds had been greater than 20 (say 100). In other words, whether normal participants and patient-controls would have overcome the risk aversion and perform using a more "cool head" approach as the number of rounds increased. Our results seem to suggest otherwise. As shown in Figure 1, normal participants and patient-controls actually seemed to decide less optimally, investing in fewer rounds, as the investment task progressed.

Our results raise several issues related to the role of emotions in risky decision-making. 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, by either discarding those that are dangerous or endorsing those that are advantageous. Emotions serve an adaptive role speeding up the decision-making process. However, there are circumstances in which a naturally occurring emotional response must be inhibited, so that a reflected, deliberate and potentially "wiser" decision can be made. The current study demonstrates this "dark side" of emotions in decision-making. On the basis of these results, we suggest that moods and emotions can play useful as well as disruptive roles in the process of making advantageous decisions, depending on the circumstances.

REFERENCES AND NOTES

1. E. Peters, P. Slovic, *Personality & Social Psychology Bulletin* **26**, 1465 (2000).
2. A. R. Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (Grosset/Putnam, New York, 1994).
3. R. J. Dolan, *Science* **298**, 1191-1194 (2002).

4. R. J. Davidson, D. C. Jackson, N. H. Kalin, *Psychological Bulletin* **126**, 890-909 (2000).
5. S. Rahman, B. J. Sahakian, N. C. Rudolph, R. D. Rogers, T. W. Robbins, *Trends in Cognitive Sciences* **6**, 271-277 (2001).
6. J. LeDoux, *The Emotional Brain: The mysterious underpinnings of emotional life.* (Simon and Schuster, New York, 1996).
7. A. Bechara, H. Damasio, D. Tranel, A. R. Damasio, *Science* **275**, 1293-1295 (1997).
8. R. D. Rogers *et al.*, *Neuropsychopharmacology* **20**, 322-339 (1999).
9. G. Loewenstein, *Organizational Behavior and Human Decision Processes* **65**, 272 (1996).
10. A. R. Damasio narrates an incident (*2*) where a patient with ventromedial prefrontal damage was driving under hazardous road conditions. While other drivers were hitting their brakes in panic on an icy patch, causing their vehicles to skid out of control, the patient crossed the icy patch unperturbed, gently pulling away from a tailspin, and driving ahead safely.
11. S. Benartzi, R. Thaler, *Quarterly Journal of Economics* **110**, 73 (1995).
12. K. Narayana, *Journal of Economics Literature* **34**, 42 (1996).
13. J. Siegel, R. Thaler, *Journal of Economics Perspectives* **11**, 191 (1997).
14. Historically, returns from stocks have been substantially higher than those for fixed income securities such as bonds. This is termed the “equity-premium puzzle” because, logically, investors should increase their investment in stocks up to the point where the risk-adjusted rate of return from the two investments is equivalent. Because of the existence of the equity premium, many financial advisers argue that the optimal way to save for the long term is to invest in a broad portfolio of stocks, irrespective of how the stock market is performing at any given point in time.
15. U. Gneezy, *Quarterly Journal of Economics* **112**, 631 (1997).
16. The patients were drawn from the Division of Cognitive Neuroscience’s Patient Registry and have been described previously (*7*). All patients have stable focal lesions, 6 in the ventromedial sector (which includes the orbitofrontal) of the

prefrontal cortex (bilateral), due to a stroke or surgical removal of a meningioma; 2 in the right insular/somatosensory area due to a middle cerbral artery stroke; and two in the amygdala (one bilateral due to Herpes Simplex Encephalitis, and one in the right amygdala due to a temporal lobectomy to treat a seizure disorder. The patient with bilateral amygdala damage also had damage to the hippocampal system, and consequently had severe anterograde memory impairment. However he has normal IQ and intellect. Analyses of our data without this patient did not affect the results. These same patients have been shown in other studies to perform poorly on the Iowa Gambling Task (*25*) and to have low emotional intelligence as measured by the EQi (*26*). Other demographic characteristics of the patients are as follows. Age: 52.9 ± 11 (mean ± SD); Years of education: 13.5 ± 3 (mean ± SD); verbal IQ: 108.6 ± 13; performance IQ: 102.5 ± 18. Demographic characteristics for normal participants are as follows: Age: 51.6 ± 13; Years of education: 14.6 ± 3 (mean ± SD); verbal IQ: 105.5 ± 7; performance IQ: 101.4 ± 10. Normal participants were recruited from the local community through participation in previous studies or advertisement in local newspapers**.** All participants provided informed consent that was approved by the appropriate human subject committees at the University of Iowa.

17. Separate analyses were carried out with all patients and with only the 6 patients with lesions in the ventromedial sector of the prefrontal cortex (PFC). The findings were similar across the two sets of analyses, albeit a bit weaker for the latter (*18*, *19*, *21*-*23*).

18. A Wilcoxon two-sample test revealed that the difference in proportions between the target patients and normal participants was significant (Wilcoxon statistic = 288.5, $P < .01$). So too was the difference in proportions between the target patients and patient-controls (Wilcoxon statistic = 44.5, , $P < .006$).

19. The average amount earned by target patients was greater than the average amount earned by normal participants, but the difference was not statistically significant ($P = .11$). The difference between the average amount earned by target patients compared to that earned by patient-controls was statistically significant (Wilcoxon statistic = 44, $P < .006$.

20. The dependent variable, *decision*, in the logistic regression 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. These variables included, *normal-control* (coded as 1 for normal participants, 0 otherwise), *patient-control* (coded as 1 for patient-controls 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 = normal-control patient-control invest-won invest-lost normal-control*invest-won normal-control*invest-lost patient-control*invest-won patient-control*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 normal participants and patient-controls compared to the target patients.

21. All the interactions in the logit model were significant: *normal-control*invest-won* [chi-square = 7.89, $P < .005$]; *normal-control*invest-lost* [chi-square = 18.1, $P < .0001$]; *patient-control*invest-won* [chi-square = 6.35, $P < .01$]; *patient-control*invest-lost* [chi-square = 21.82, $P < .0001$].

22. Target patients vs. normal participants: Wilcoxon statistic = 293.5, $P < .005$; target patients vs. patient-controls: Wilcoxon statistic = 45, $P < .006$.

23. Target patients vs. normal participants: Wilcoxon statistic = 280, $P < .02$; target patients vs. patient controls: Wilcoxon statistic = 67.5, $P = .16$).

24. G. F. Loewenstein, E. U. Weber, C. K. Hsee, N. Welch, *Psychological Bulletin* **127**, 267-286 (Mar, 2001).

25. A. Bechara, H. Damasio, A. Damasio, in *The Amygdala in Brain Function: Basic and Clinical Approaches* P. Shinnick-Gallagher, A. Pitkanen, A. Shekhar, L. Cahill, Eds. (Annals of the New York Academy of Science, New York, 2003), vol. 985, pp. 356-369.

26. R. Bar-On, D. Tranel, N. Denburg, A. Bechara, *Brain*, in press (2003).

27. We gratefully acknowledge a suggestion from C. Hsee that sparked the idea for this study, and T. Gruca and G. Russell for their suggestions on analyzing our data. Supported by a grant from the National Institute of Health (NINDS) PO1 NS19632.

Table 1

Percentage of decisions to invest following what occurred on previous rounds

Previous Round	Target Patients	Normal Participants	Patient-Controls
No Invest	74.2%	70.2%	63.4%
Invest & Lost	85.2%	46.9%	37.1%
Invest & Won	84.0%	61.4%	75%

Figure 1

Percentage of rounds in which participants decided to invest $1