Investment Behavior and the Negative 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)

Address correspondence to Baba Shiv, Department of Marketing, PBB S336, University of Iowa, Iowa City, IA 52242-1000; Phone: (319) 335-0932, Email: baba-shiv@uiowa.edu

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Can dysfunction in neural systems subserving emotion lead, under certain circumstances, to more advantageous decisions? To answer this question, we investigated how normal participants (normal-controls), 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 (patient-controls) made 20 rounds of investment decisions. Target patients made more advantageous decisions and ultimately earned more money from their investments than the normal-controls and patient-controls. When normal-controls and patient-controls either won or lost money on an investment round, they adopted a conservative strategy and became more reluctant to invest on the subsequent round, suggesting 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; G. 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 (G. Loewenstein, 1996), 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 (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). An example described by Damasio (Damasio, 1994) concerns a patient with ventromedial prefrontal damage who 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. 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 this 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). Most people display extreme levels of risk aversion toward gambles that involve some possible loss, when the gambles are presented one-at-a-time, 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).

Based on 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), and on 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, which do not impair their emotional responses), when faced with the types of positive expected value gambles highlighted above. In 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, as is common, where 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 in previous research to demonstrate myopic loss aversion (Gneezy, 1997), was designed so that that it would behoove participants to invest in every single 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, make more advantageous decisions, and, thus, earn more money by investing in more rounds 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, 15 target patients with chronic and stable focal lesions in specific components of a neural circuitry that included either the amygdala (bilaterally; 3 patients), the orbitofrontal cortex (bilaterally; 8 patients), or the right insular/ somatosensory cortex (4 patients), which have 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). 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 or left dorsolateral sector of the prefrontal cortex.

The patients were drawn from the Division of Cognitive Neuroscience's Patient Registry and have been described previously (Bechara et al., 1997). All target patients have stable focal lesions in the ventromedial sector (which includes the orbitofrontal) of the prefrontal cortex, due to stroke or surgical removal of a meningioma; the right insular/somatosensory region due to stroke; or the amygdala 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. Analyses of our data without these patients did not affect the results.) The control patients have lesions in the right (4 patients) or left (3 patients) dorsolateral sector of the prefrontal cortex due to stroke. All target patients have been shown in other studies 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 (Bar-On et al., 2003; Bechara et al., 2003). 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. Normal participants were recruited from the local community through advertisement in local newspapers. None had any history of neurological or psychiatric disease (assessed by questionair) and their demographic characteristics 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. 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, each participant was 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 make a decision between two options: invest $1 or not invest. If the decision were <u>not to invest</u>, they would keep the dollar, and 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 were heads (50% chance), then they 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 the investment task is such 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). 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

Rounds Invested and Amounts Earned

Examination of the proportion of the 20 rounds in which participants decided to invest reveals that the target patients made decisions that were closer to a profit-maximizing viewpoint (see Table 1). Specifically, target patients invested in 83.7% of the rounds on average, as compared to normal participants who invested in 57.6% of the rounds (Wilcoxon two-sample test statistic = 345.0, $p < .002$), and patient-controls who 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 ($22.8, Wilcoxon statistic = 315.5, $p < .03$) or patient-controls ($20.07, Wilcoxon statistic = 44, $p < .006$; the average amount earned by normal participants was no different than that earned by patient-controls; Wilcoxon statistic = 73, p = n.s.).

Figure 1 shows the proportion in which participants decided to invest in four blocks of 5 rounds each. The pattern of results suggests that all three groups of participants started off with the investment task closer to the normative benchmark. However, unlike target patients who remained close to the normative benchmark, normal participants and patient controls 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 patients controls. Target patients, on the other hand, did not experience these emotions and were, thus, unaffected by the outcomes of preceding rounds when they made decisions on subsequent rounds. We examine this potential account in greater detail in the next section.

Impact of Outcomes on Previous Rounds on Decisions in Subsequent Rounds

A lagged logistic regression analysis was carried out 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 more so for normal participants and patient controls than for target patients. 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, *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*invest-won 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 control participants.

Both interactions in the logit model were significant: *control*invest-won* (chi-square = 10.27, *p* < .001); *control*invest-lost* (chi-square = 31.98, *p* < .0001). These results suggest 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 normal-controls, patient-controls and target patients who invested as a function of the decision/outcome on the previous round, normal-controls 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, normal participants invested in only 40.5% of rounds (Wilcoxon-statistic = 350.0, *p* < .001), and patient-controls invested in only 37.1% of rounds following such losses (Wilcoxon-statistic = 45, *p* < .006). Similarly, compared to target patients who invested in 84% of rounds following wins, normal participants invested in only 61.7% of rounds (Wilcoxon-statistic = 323, *p* < .01), and patient-controls invested in 75% of rounds following such wins (Wilcoxon-statistic = 67.5, *p* = .16). 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: 61.7% vs. 40.5%, a difference of 21.2%; 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%).

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 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 (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, recent treatments have 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 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 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 the process of making advantageous decisions. It is important to note that previous experiments that demonstrated a positive role of emotion in decision-making involved tasks of decisions under ambiguity (i.e., the outcome is unknown) (Bechara et al., 1997). In the present experiment, the patients were tested using tasks of decisions under uncertainty (i.e., the outcome is risky but it is defined by some probability distribution). We do not know at this point whether the neural mechanisms for decisions under uncertainty and ambiguity draw upon different neural processes, so that emotion is disruptive to one mechanism, but not the other. Regardless, it is not a simple issue of trusting emotions as the necessary arbiter of good and bad decisions. It is a matter of discovering the circumstances in which emotions can be useful or disruptive, and using the reasoned coupling of circumstances and emotions as a guide to human behavior.

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Table 1

Percentage of decisions to invest—overall and following what occurred on previous rounds

	Target Patients[1]	Normal Participants	Patient-Controls
Decision to invest—-Overall	83.7%	57.6%	60.7%
No Invest on previous round	74.2%	64.4%	63.4%
Invest & Lost on previous round	85.2%	40.5%	37.1%
Invest & Won on previous round	84.0%	61.7%	75%

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[1] The results within the three groups that comprised target patients—orbitofrontal (n = 8), insular/somatosensory (n = 4), and amygdala (n = 3), respectively, were as follows. Decision to invest—Overall: 79.4, 91.3, and 85.0%; No Invest on previous round: 70.4%, 70.0%, and 83.3%; Invest & Lost on previous round: 79.8%, 96.8%, and 84.3%; Invest & Won on previous round: 79.1%, 94.4%, and 83.3%.

Figure 1

Percentage of rounds in which participants decided to invest $1