The Emotional Information Processing System is Risk Averse: Ego-Depletion and Investment Behavior

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THE EMOTIONAL INFORMATION PROCESSING SYSTEM IS RISK AVERSE:

EGO-DEPLETION AND INVESTMENT BEHAVIOR

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Short Abstract

Two experiments show that a shortage of self-regulatory resources results in more risk aversion in mixed-gamble (gain/loss) situations. The findings support a dual-process view that distinguishes between a rational and an affective information processing system, in which self-regulatory resources are the necessary fuel for the rational system. Depending on the expected values of risk seeking versus risk averse behavior, ego depletion can have negative (experiment 1) as well as positive (experiment 2) consequences for investment behavior.

Extended Abstract

Previous research has shown that self-regulatory strength is crucial to exert willpower. It has been found that a depletion of self-regulatory resources very often leads to detrimental behavior such as overeating and impulsive buying (Vohs and Faber 2007; Vohs and Heatherton 2000). However, not much is known about how the availability of these resources is related to risky decision making. The current research shows that a state of ego-depletion leads to higher levels of risk aversion in mixed gambles (involving mixtures of gains and losses).
Risk aversion for mixed gambles refers to the tendency of people to reject a gamble with an equal chance to win or to lose, even when the expected value of gambling is higher than the expected value of not gambling (Tversky and Kahneman 1992). Recent developments in the field of neuroscience and psychology indicate that anticipatory emotional reactions that are elicited by features of the risky decision alternatives are crucial in understanding risk taking and risk seeking (Damasio 1994; LeDoux 1996; Loewenstein et al. 2001).
In the current research, we adopt a dual-process framework that distinguishes between a rational (cognitive) and an experiential (emotional) information processing system (Epstein and Pacini 1999), in order to explain greater risk avoidance in a state of ego-depletion. In a situation where one has to make a choice between a risky and a less risky alternative, both the rational and the experiential system generate an "advice" concerning the most desirable behavior. The outcome of the rational system is determined by a cognitive assessment of probabilities of decision outcomes and outcome severity, whereas the outcome of the experiential system is determined by an automatic retrieval of accumulated knowledge from previous experiences. Since the experiential system attaches greater weight to previously experienced negative contingencies than to previously experienced positive contingencies of the choice options (De Houwer, Thomas, and Baeyens 2001), it guides the decision maker away from risky alternatives. Given that the rational system is the slower, analytical system it is in an ideal position to monitor and inhibit the output of the faster, associative experiential system. However, building on previous research that puts forward self-regulatory resources as the necessary fuel for the rational system (Vohs 2006), we hypothesize that a depletion of self-regulatory resources impairs the inhibiting capacity of the rational system. As a consequence, the output of the experiential system is weighted more heavily in the final decision, resulting in more risk aversive behavior among ego-depleted individuals.
Two experiments provide support for this reasoning. In both experiments, the availability of self-regulatory resources was manipulated by a modified version of the Stroop task (Stroop 1935). Inhibiting first responses (which is the general purpose of this task) has been shown to consume self-regulatory resources (e.g., Inzlicht and Gutsell 2007; Muraven, Tice, and Baumeister 1998; Wallace and Baumeister 2002), and is therefore an effective way of inducing a state of ego-depletion.
In Study 1, the Stroop task was followed by an investment task which has previously been used to compare decision making of patients with lesions to the brain's emotional circuitry and patients with substance dependence to decisions made by a normal control group (Shiv et al. 2005a; Shiv et al. 2005b). The task consists of 20 decision rounds in which one can choose between investing $1 or not investing $1. An investment decision

is followed by a coin toss; heads results in losing the $1, tails results in gaining $2.50. If a participant decides not to invest, the game advances to the next round. Since the expected value of risk seeking behavior (invest) is higher than the expected value of risk aversive behavior (not invest), a rational decision maker should always decide to invest.
Participant's predisposition to rely on experiential processing was measured with the experientiality subscale of the Rational-Experiential Inventory (Pacini and Epstein 1999). As the experiential system is an associative information processing system that generates emotional responses based on previous outcomes, we only expected it to influence investment decisions of depleted participants after some experience with the task at hand (i.e. in the second block of 10 trials). Additionally, we expected a moderation of the effect by experientiality. Indeed, if the weighting of the outcomes of the experiential system is dispositionally low, the rational monitoring system should still be able to override the responses generated by the experiential processing system.
As predicted, the three-way interaction between state of self-regulation (control; depleted), experientiality (high; low) and decision block (first block of 10 decisions; second block of 10 decisions) was significant. After having gained some experience with the investment task, ego-depleted participants with a tendency to rely on their experiential "hunches" clearly showed higher levels of risk aversion.
The goal of the second study was to demonstrate that a lower availability of self-regulatory resources can be beneficial for decision making in a situation where the expected value of risk avoidant behavior is higher than the expected value of risk seeking behavior. After completing the modified Stroop task, participants continued with the Iowa Gambling Task (see Bechara et al. 1994, for exact procedures and pay-off structure). Participants had to choose 100 times between cards from four different decks. Two decks are low-risky decks with a high expected value, and two decks are high-risky decks with a lower expected value. Results showed that ego-depleted participants selected significantly more cards from the low-risky decks with a higher expected value.
In sum, in two experiments we showed that a lower availability of self-regulatory resources increases risk aversion in mixed gambles (study 1 & study 2). This finding can be explained by an increased weighting of experiential processing in decision making (study 1) and implies that ego-depletion is not always detrimental for decision making, but can also guide people towards more beneficial choice options (study 2).

THE EMOTIONAL INFORMATION PROCESSING SYSTEM IS RISK AVERSE: EGO-DEPLETION AND INVESTMENT BEHAVIOR

An extensive body of research has shown that self-regulatory resources can easily be depleted by short actions of self-control resulting in a state of ego-depletion (Baumeister 2002; Baumeister et al. 1998; Muraven et al. 1998). Prior research has focused primarily on the consequences of ego-depletion on the ability to exert willpower. The general finding is that breakdowns in self-regulatory efforts due to prior exertion of willpower and the coinciding consumption of precious self-regulatory resources make people place less weight on their long-term goals and plans. As a consequence, people behave more impulsively in order to alleviate immediate urges and desires, which can result in detrimental behaviors like impulsive spending (Vohs and Faber 2007), overeating (Vohs and Heatherton 2000) or increased alcohol consumption (Muraven, Collins, and Nienhaus 2002).

Not much is known, however, about the consequences of a state of ego-depletion for decisions made under uncertainty. In this article, we investigate how the availability of self-regulation strength is related to risk seeking and risk aversion in "mixed" gambles (involving mixtures of gains and losses). We adopt a dual-process framework that models behavior as a joint function of the outcomes of a rational and an emotional information processing system and build on previous research that puts forward self-regulatory resources as the necessary fuel for the rational system to work (Vohs 2006). Risk attitudes of ego-depleted participants and control participants are compared in two risky decision-making tasks that simulate real-life investment decisions.

THEORETICAL BACKGROUND

In the past 25 years, the judgment and decision making literature has invested a lot of effort in uncovering irrationalities of human decision making. One typical finding is that most people irrationally reject a gamble with equal chances to win and lose, even when the expected value of gambling is larger than the expected value of the status quo, a phenomenon called risk aversion (Tversky and Kahneman 1992). These irrationalities of human choice have cast serious doubt on the long-standing rational, normative view on economic decision making in which consumers are described as economic actors that select alternative options with the highest expected utility or value (Von Neumann and Morgenstern 1944).

Prospect Theory explains the tendency to be risk averse for “mixed” (gain/loss) gambles using the concept of loss aversion, which is popularly phrased as the fact that losses loom larger than gains (Kahneman and Tversky 1979). Loss aversion refers to the fact that the aggravation one experiences when losing a sum of money is greater than the pleasure associated with gaining the same amount of money. Therefore decision makers confronted with a gamble offering a 50/50 chance to either gain or lose $50 are expected to be risk averse and reject the gamble (Kahneman and Tversky 1984).

However, Prospect Theory does not explain why human beings are loss averse. Recent theoretical developments in the field of neuroscience and psychology highlight the role of anticipatory emotional reactions that are elicited by features of risky decision alternatives (Damasio 1994; LeDoux 1996; Loewenstein et al. 2001). It is argued that these affective responses are more rapid and basic than cognitive evaluations and are often used as proxies for value. By providing a rapid and crude assessment of the behavioral options an organism is faced with, these affective responses exert a direct influence on behavior: things that feel good must be approached, and things that feel bad must be avoided. Whereas the rational perspective holds that preferences for certain decision alternatives result from logical inference or cost-benefit analysis, the emotional perspective proposes that likes and dislikes are acquired from previous experience through associative learning or conditioning (De Houwer et al. 2001).

These conditioned emotional responses are said to be crucial in explaining loss aversion and the resulting risk aversive tendency in mixed-gambles situations. Evidence for this argument stems mainly from neuropsychological research comparing patients with lesions to the brain's emotional circuitry, including amygdala and ventromedial prefrontal cortex, with normals in experimental risky decision-making tasks (Bechara et al. 1999; Bechara et al. 1997; Shiv, Loewenstein, and Bechara 2005a; Shiv et al. 2005b). This research typically finds that lesion patients tend to be more risk seeking relative to a normal control group, providing support for the claim that brain structures involved in emotional information processing are crucial in understanding risky decision making.

Attempts to incorporate the rational and affective perspective in one theoretical framework typically propose that human beings have two information processing systems. For example, Cognitive-Experiential Self-Theory (CEST) proposes that people's behavior is determined by the outcomes of two different information-processing systems, a preconscious "experiential system" and a conscious "rational system" (Epstein 1994). Whereas the rational system is an affect-free, slow and analytical inferential system, the experiential system is a rapid, associative learning system that is intimately related with affect.

The experiential and the rational system do not have identical determinants nor do they have equal consequences for risky behavior. When a person has to make a decision between a certain and a risky option, the experiential system automatically retrieves accumulated knowledge from previous experiences with the decision alternatives under consideration. The affective reactions triggered by this associative retrieval process guide behavior towards desirable outcomes and away from undesirable ones. The rational system, on the other hand, depends more on objective probabilities of outcomes and assessments of outcome severity. Thus, whereas the reactions of the experiential system depend on personal exposure to the outcomes under consideration and the past history of conditioning, the outcomes of the rational system are determined by objective features of the risky situation.

As a consequence, the responses of the experiential system to an identical situation are expected to change over time depending on previous experience with that situation, whereas the reaction of the rational system should be stable under unchanged objective features of the decision situation. Since there is a general bias in animals and humans to give greater weight to negative contingencies (losses) than to positive contingencies (gains) (De Houwer et al. 2001; Rozin and Royzman 2001; Tom et al. 2007), the experiential learning system is likely to become more loss aversive over time resulting in more risk aversion for mixed gambles.

Given that the rational system is the slower information processing system, it is in an ideal position to monitor the output of the experiential system and correct it if necessary (Epstein 2003; Kahneman and Frederick 2002). Recently, self-regulatory resources have been put forward as the crucial fuel for the cognitive system (Vohs 2006).

When sufficient resources are available, the output of the experiential system is being closely monitored by the rational system and can be overridden if necessary; however, when resources are scarce the monitoring capacity of the rational system is reduced and the experiential system's output should be weighted more heavily in the final decision (Strack, Werth, and Deutsch 2006).

It is well-established that self-regulatory resources can easily be depleted by short actions of self-control resulting in a state of ego-depletion (Baumeister 2002; Baumeister et al. 1998; Muraven et al. 1998). In this research we compare risk attitudes of ego-depleted participants and control participants in two risky decision-making tasks that simulate real-life investment decisions in the way they factor uncertainty, rewards, and punishments. These tasks have previously been used to compare brain-damaged patients with normal individuals in terms of risky behavior, and typically find that patients with lesions to the neural system subserving emotion show more risk seeking behavior. Because these abnormalities may represent extreme ends of a normal continuum of information processing, results with clinical patients can illuminate issues in the normal population. Indeed, if the absence of affective responses due to dysfunctions in the emotional brain circuitry results in reduced levels of risk aversion, it is likely that for normal participants a higher emotional reactivity due to a depletion of self-regulatory resources may result in increasing levels of risk aversion. Such a finding would provide support for the idea that self-regulatory resources indeed power the rational system and that a depletion of these resources unleashes the experiential, affective processing system establishing itself in more risk aversion.

STUDY 1

The purpose of the first study was to (1) provide empirical evidence that a temporary reduction in self-regulatory resources increases risk aversion for mixed gambles and (2) explore what underlies this risk aversion by examining whether the effect is moderated by experience with the gambling situation and by a person's tendency to rely on the output of the experiential system.

In this study, we adopted a risky decision making task that has previously been used to compare patients with brain damage to the emotional circuitry and individuals with substance dependence with a normal control group in terms of risk taking and risk aversion (Shiv et al. 2005a; Shiv et al. 2005b). The task consists of 20 rounds of investment decisions in which participants have to make a choice between two options: invest $1 or don't invest $1. A risk seeking decision to invest is followed by a coin toss, with an outcome of heads resulting in a loss of $1 and an outcome of tails resulting in a gain of $2.50. If a participant is risk averse and decides not to invest, the task advances to the next round. Notice that on each round the decision maker is fully aware of the contingencies associated with gambling or not gambling and that these contingencies are held constant over time. This makes the task especially suited to test our main predictions.

Moderation by experience with the task

In the initial stages of the task we do not expect to find a difference between ego-depleted participants and control participants in terms of risk preferences. Indeed, since the responses of the experiential system are shaped through prior experience according to the principles of associative learning and since the task is completely new, the experiential information processing system does not yet generate an affective response towards the behavioral options; hence in both ego-depleted and control participants the affective output of the experiential processing system is expected to be minimal. The investment decision can only be determined by a computation of the expected value for each decision alternative. As the expected value of a risk seeking choice ($1.25) is higher than the expected value of a risk avoidant choice ($1), the behavioral response should be to invest. However, as the task progresses and participants gain experience with the outcomes of the decision options, the experiential system starts generating affective responses towards the choice options. Given the higher emotional reactivity to losses than to gains (De Houwer et al. 2001; Tom et al. 2007), the experiential system guides behavior away from the risky decision alternative and towards the more certain option. This risk avoidant experiential "advice" will be weighted more heavily in the final decision of participants who are low in self-regulatory strength because of the reduced capacity of their rational system to inhibit affective responses.

Moderation by experientiality

Among depleted participants, the impact of anticipatory emotional reactions on the final decision will be weaker for individuals with a predispositional tendency to suppress experiential processing. Indeed, we expect that these individuals are able to inhibit weak experiential reactions even when their self-regulatory resources are reduced. However, ego-depleted participants attaching greater value to the experiential processing system should show a significant reduced propensity for risky behavior relative to control participants after having gained some experience with the task.

Note that the task provides a conservative test for our hypothesis in two ways. First, since monetary payoffs promote a rational processing mode by virtue of its fungibility the task may reduce loss aversion effects (Rozin et al. 2007). Second, participants are explicitly told about the payoff structure of the task. A computation of the expected value for each choice alternative is straightforward and likely to reduce the impact of anticipatory emotional signals (Bechara 2004).

Method

Design and participants. The design of this study was a two-factor design with ego-depletion manipulated between subjects and level of experiential processing measured as a continuous variable. Sixty-four undergraduate students participated for course credit (27 females and 37 males, for age, $M = 20.95$, $SD = 2.01$)

Procedure. Students were run individually in experimental cubicles and were informed that they would participate in a study consisting of two unrelated games, a color game and an investment game. The color game was in fact a modified Stroop Task, designed to manipulate ego-depletion.

Before starting the Stroop task, participants were asked to complete a short questionnaire, intended to measure experientiality. The items for this measure were sampled from the experientiality subscale of the Rational-Experiential Inventory (Pacini and Epstein 1999). This scale measures to what extent an individual is inclined to weigh the outcomes of the experiential system in decision making. Because of time limitations, we selected 8 items from the 24 original items. Four items were positively scored (e.g., “I like to rely on my intuitive impressions”, “I tend to use my heart as a guide for my actions”), while the four other items were reverse-scored (e.g., “I don’t have a very good sense of intuition”, “I don’t think it is a good idea to rely on one’s intuition for important decisions”). Items were rated on a 5-point scale that ranged from 1 (*definitely not true of myself*) to 5 *(definitely true of myself).*

In order to induce a state of ego-depletion, we used a modified version of the Stroop task (Stroop 1935). Participants were instructed to indicate the ink color in which color names were written in 75 consecutive trials. Words and ink colors were either matched (e.g., RED in red ink; control condition) or mismatched (e.g., RED in yellow ink, depleting condition). In addition, in the depleting condition, participants were instructed to indicate the word rather than the ink color whenever a word in blue ink appeared, which was the case in 25% of the trials. Notice that the Stroop task perfectly illustrates the supervisory role of the rational system outlined above. Participants in the mismatch condition tend to stumble because the word is automatically read and activates a response that is in competition with the required response. Successful monitoring and correction by the rational system is needed in order to avoid errors. This monitoring process in Stroop task consumes self-regulatory strength (e.g., Inzlicht and Gutsell 2007; Muraven et al. 1998; Wallace and Baumeister 2002). Five participants who clearly did not understand the instructions of the Stroop task were not considered in further data analysis. These participants erred on more than 25% of the trials and together they accounted for more than 70% of the total amount of errors that were made in the Stroop task.

When a participant had successfully completed the Stroop task, s/he was invited to participate in an investment game (Shiv et al. 2005a; Shiv et al. 2005b). At the start of the game, every participant was endowed with $20 of play money. Participants were informed that they would be making several rounds of investment decisions. In every round, they would have to make a decision between investing \$1 and keeping \$1. If a participant decided to invest, a coin would be tossed. If the outcome of the toss was heads, the participant would lose the \$1 that he or she invested. However, if the outcome was tails, \$2.50 was added to the participant's account. If a participant decided not to invest, the game would advance to the next round. The game was stopped when a participant had gone through 20 rounds of investment decisions.

Results

In order to analyze how investment behavior evolved over time, the 20 rounds of investment decisions were broken down in 2 blocks of 10 decisions. For experientiality, we averaged the scores on the 8 items ($\alpha = .77$) and assigned individuals to the low and high experientiality conditions based on a median split. The data were analyzed with a 2 (state of self-regulation: control, depleted) x 2 (block: first, second) x 2(experientiality: high, low) mixed ANOVA, with state of self-regulation and experientiality as between-subjects factors and block as a within-subject factor. Because a number of studies have found that male individuals tend to be more risk averse than female individuals (see Byrnes, Miller, and Schafer 1999, for a meta-analysis), gender was added to the model as a control variable.

This analysis yielded the predicted three-way interaction between experientiality, initial task and block ($F(1, 54) = 3.97$, $p = .05$). Gender did not have a significant effect on the total amount of investments ($F(1, 54) = 1.15$, $p = .29$), nor did it interact with block ($F(1, 54) = 1.01$, $p = .32$), and was therefore dropped from the model for further analysis

We hypothesized that the experiential system should be responsible for a decrease in investment decisions among depleted participants. Because the experiential system is a learning system generating emotional responses that are acquired through previous experience, we only expected an increased level of risk aversion after having gained some experience with the task. In line with this reasoning, we found a significant interaction between experientiality and state of self-regulation in the second block ($F(1, 55) = 3.77$, $p = .05$), whereas this interaction was not significant in the first block ($F(1, 55) = 0.05$, $p = .82$). After having gained some experience with the task, highly experiential individuals who were depleted of self-regulatory resources were significantly more risk averse – and thus made fewer investment decisions – than highly experiential control participants (4.92 vs. 7.33), ($F(1, 55) = 4.45$, $p < .05$). No effect of self-regulatory depletion was apparent for low experiential respondents ($F(1, 55) = 0.35$, $p = .56$). The absence of an effect of depletion on risk preferences in block 1 and the moderation of the depletion effect by experientiality in block 2 provides strong support for the crucial role played by the experiential system in the development of risk aversion in mixed gambles. Table 1 provides an overview of all the cell means and standard deviations.

Table 1. Overview of means and standard deviations per block of 10 investment decisions

			Block 1		Block 2	
		N	Mean	SD	Mean	SD
Control	Low Experiential	20	7.80	2.09	7.20	2.46
	High Experiential	15	7.73	1.71	7.33	3.33
Depletion	Low Experiential	12	8.92	1.16	7.83	2.94
	High Experiential	12	8.00	2.41	4.92	3.20

Discussion

The results of study 1 show that depletion of the self-regulatory resources that power the rational monitoring system causes more risk aversive behavior (i.e., fewer investment decisions) in mixed-gambles situations. The fact that this effect does not show immediately but only emerges after gaining some experience with the possible outcomes of different decision alternatives is in line with the reasoning that conditioned anticipatory emotional reactions are underlying risk aversion. This claim is further supported by a moderation of the effect by experientiality.

The findings support a rational-experiential dual-process model in which the rational system monitors and corrects the outcomes of the experiential system. When self-regulatory resources are available, or the value attached to experiential input is low, decisions are made under rational control and based on a cognitive assessment of expected value. However, after depleting self-regulatory resources the experiential system is "free" from the controlling rational system. Participants who have a dispositionally strong reliance on the experiential system will then be disproportionally influenced by the experiential system's aversion to negative outcomes and make fewer investment decisions in situations where it would clearly be optimal to invest

STUDY 2

The goal of study 2 was twofold. First, we wanted to generalize the findings of study 1 to a decision situation in which the reward/punishment contingencies of different choice options is opaque. This external validity check is important since in most real-life situations one is not perfectly aware of all possible decision outcomes and their respective probabilities of occurrence. Second, we wanted to demonstrate that people with low self-regulatory resources can make more advantageous decisions than people with high self-regulatory resources. Indeed, whether a risk aversive decision strategy due to higher emotional reactivity is advantageous or disadvantageous is dependent on the objective expected value that is paired with risk aversive and a risk seeking decisions (Loewenstein et al. 2001). When risk aversive choices have a higher expected value relative to risk seeking choices, an individual should benefit from having a reduction in self-regulatory strength.

In order to accomplish these research objectives, we compared decisions made by depleted participants with decisions made by control participants in the Iowa Gambling Task (Bechara et al. 1997). This task requires a person to repeatedly choose a card from four decks of cards. Each card brings a certain gain and some cards also bring losses. The objective of the game is to gain a maximum amount of money. Two of the four decks are highly risky and have a negative expected value because they bring high rewards but even higher penalties. The other two decks are less risky, featuring smaller payoffs, but even smaller penalties, hence a positive expected value. Importantly, the reward/punishment schedule is unknown to participants. This makes a cognitive assessment of the expected value of the four choice options impossible.

Previous research using this experimental paradigm has indicated that individuals with an intact emotional processing system tend to perform better relative to individuals with emotional dysfunctions because normal individuals take less risks that result in catastrophic losses (Bechara et al. 1994). A correlation between the development of anticipatory skin conductance responses generated by the ventromedial prefrontal cortex and performance in the decision making task (Bechara et al. 1997), signals the importance of anticipatory emotional reactions and the "emotional" brain for successful performance in this task. Analogous to these clinical findings, we expect that boosting the impact of the more emotional experiential system by depleting healthy participants' self-regulatory resources prior to engaging in the Iowa Gambling Task should lead to more risk avoidance, hence enhanced performance in this task. Contrary to the gambling task in experiment 1, this time a rational computation of the expected value of available choice options is impossible from trial 1. Instead, participants have to learn the payoff structure in the Iowa Gambling Task from experience. Depleted participants' greater sensitivity to risk should lead them to pick from the safer decks almost from the very beginning.

Method

Design and participants. Fifty-seven undergraduate students (32 men and 25 women, for age, $M = 21.28$, $SD = 2.06$) at a large university participated in this study in exchange for course credits or a monetary payment of $3. Participants were run in individual sessions of approximately 20 minutes. They were told that they would participate in a study that consisted of two unrelated games: a color game and a gambling game.

Procedure. As in study 1, ego-depletion was manipulated between subjects by means of a control and a depleting version of the Stroop task. After completing the Stroop task, participants were invited to engage in a computerized version of the Iowa Gambling Task (see Bechara et al. 1994, for the exact payoff structure of this task).

Participants were endowed with $2000 of play money. The game required from a participant to make a long series of card selections from four decks of cards until they were told to stop (after turning 100 cards). With every card a participant turned, he or she won a certain amount of money, depending on which deck was selected. Participants were instructed to try to maximize profits. Turning any card from deck A or B was rewarded with $100 and turning a card from deck C or D yielded $50. After turning some cards, the participants both won and lost an amount of money. Like the gains, these losses also varied with the deck, but unlike the gains, they also changed with the position in the deck, according to a schedule unknown to the participants. The punishments that a participant encountered in deck A and B were higher than the punishments in deck C and D. Turning a card from deck A or B was more risky than turning a card from deck C or D since the first were associated with higher punishments and with higher rewards, while the latter yielded lower punishments and lower rewards. The deck contingencies were fixed in such a way that turning 10 cards from deck A or B incurred a net loss of $250. Indeed, turning 10 cards from deck A or B resulted in a total punishment of $1250, while turning 10 cards from deck C or D only resulted in a total loss of $250. Hence, turning 10 cards from deck C or D, on the other hand, resulted in a net gain of $250. While each card of deck A and B yielded a higher monetary reward than each card of deck C and D, in terms of expected value it was still better to draw cards from decks C and D since the penalties that were tied to deck A and B were also higher. In short, decks A and B can be regarded as high-risk decks whereas decks C and D can be considered as low-risk decks. By choosing exclusively from the low-risk decks, a participant could maximize profit.

Results

We expect the effect of depletion on investment decisions to be limited in time for two reasons. First, previous research has shown that repeatedly making deliberate choices is depleting by itself (Bruyneel et al. 2006). Thus, even control participants can be expected to become depleted during a task in which 100 decisions have to be made. Second, after a sufficient number of samples the payoff structure of the different decks will become clear and with it the rationality of picking from decks C and D only. Therefore, we only expected to find a difference in the initial stages of the game and considered the first 40 choices that were made by each participant for analysis. As in conventional analyses of Iowa Gambling Task performance (Bechara et al. 1994),we computed a net score by subtracting the number of risky from non-risky card selections [(C+D)-(A+B)]. A higher net score implies a more risk averse and advantageous decision strategy.

A one-way ANOVA (Initial task: control, depleting) was conducted with the net score obtained in the Iowa Gambling Task as the dependent measure. Gender was again included in the model as a control variable. This analysis yields a main effect for state of self-regulation ($F(1, 54) = 3.82$, $p = .05$). Individuals who had to exert self-control in the first part of the study performed better ($M = 1.14$) than those who did not exert self-control in the initial task ($M = -6.34$). The effect of gender was not significant ($F(1, 54) = 0.93$, $p = .34$).

As expected we could not find a significant difference between depleted and control participants after having made 40 choices, although depleted participants still showed directionally more risk avoidant behavior at this later stage of the game than control participants (10.43 vs. 7.38), ($F(1, 54) = 0.27$, NS).

Discussion

The results of study 2 demonstrate that ego-depletion is advantageous for decision making when the expected value of risk aversive choices is higher than the expected value of risk seeking choices. Unlike in study 1, there was no perfect knowledge about the reward structure of the task. Therefore, a rational computation of the expected value for each decision alternative was not possible. Even in this case, where experiential information processing is an evident alternative for depleted as well as control participants, depleted participants showed markedly higher levels of risk aversion.

GENERAL DISCUSSION

Our findings provide support for a dual process account of human decision making. This theory argues that human decisions are driven by two systems, one rational, symbolic, slow and resource-dependent and the other one experiential, intuitive, emotional, more automatic and associative. When ample resources are available, the rational system monitors the output of the experiential system. When self-regulatory resources are scarce, the intuitive system's output will have a larger weight in the decision making process. Building on evidence that the experiential contingency learning system is highly sensitive to negative outcomes (De Houwer, Baeyens, and Field 2005; Tom et al. 2007), we hypothesize and find that in a state of ego depletion, when self-regulatory resources are scarce, people become more risk averse.

The involvement of the experiential system was most clearly demonstrated in the first experiment. In a task where investing is clearly the rational thing to do because it has a higher expected value than not investing, we find that investment decisions can be thwarted by the experiential system, provided that the resources for the analytical system are low and a person's dispositional tendency to rely on the experiential system is high.

However, the experiential system's sensitivity to negative outcomes most likely has a sound evolutionary basis. When self-regulatory resources are low, it makes good sense for an organism to behave prudently. In many situations, being risk averse pays off more than being risk seeking, and in such situations people in a state of ego depletion might actually outperform their non-depleted peers. Indeed, this is what we showed in our second experiment, involving the Iowa Gambling Task. The Iowa Gambling Task is an investment situation in which people choose repeatedly between high risk (high gains with high losses) and low risk (low gains with low losses) options, and only after substantial experience with the task does it become clear to decision makers that the low risk options have a positive expected value and the high risk options have a negative expected value. The risk aversion of people in a state of ego depletion helps them pick more often from the good decks right away

Our results possibly bear a positive implication for gambling behavior. Generally considered a form of impulsive behavior (Baumeister and Heatherton 1996), gambling behavior can be expected to increase in a state of ego depletion (Strack et al. 2006), with potentially dire consequences. Indeed, the many choices and decisions involved in typical gambling situations can be expected to lead to an increased state of ego depletion (Bruyneel et al. 2006) which – if impulsive behavior would simply be unleashed – would result in a negative spiral of gambling investments. The increased risk aversion generated by ego depletion, especially among individuals with a greater tendency to rely on experiential processing, might be a powerful antidote to this otherwise self-destructive pattern.

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