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Self-Control Moderates Decision-Making Behavior When Minimizing Losses versus Maximizing Gains

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ABSTRACT

We examined (1) whether people would be more responsive to the delayed consequences of their decisions when attempting to minimize losses than when attempting to maximize gains in a history-dependent decision-making task and (2) how trait self-control would moderate such an effect. In two experiments, participants performed a dynamic decision-making task where they chose one of two options on each trial. The *increasing* option always gave a smaller immediate reward but caused future rewards for both options to increase. The *decreasing* option always gave a larger immediate reward but caused future rewards for both options to decrease. In Experiment 1 where the two options had equivalent expected value in the long run, participants were more prone to select the increasing option, which yielded larger benefits on future trials, in the loss-minimization condition than in the gain-maximization condition. Trait self-control moderated the effect of losses by enhancing the effect for low self-control participants while attenuating it for high self-control participants. In Experiment 2 where selecting the increasing option was suboptimal, low self-control participants still attempted to reduce losses on future trials by selecting the increasing option more often than high self-control participants. These results suggest that decision makers value delayed consequences of their actions more in a losses domain relative to a gains domain and low self-control individuals are more susceptible to such an effect. Copyright © 2014 John Wiley & Sons, Ltd.

KEY WORDS loss aversion; gains; losses; decision making; self-control; experience-based

INTRODUCTION

Our decisions can have both immediate and long-term effects. One prevalent challenge decision makers are faced with is that choices appearing attractive in the short term may not turn out to be the best choices in the long run. For instance, after a long day of work, we may face a decision between lying on the couch versus going to the gym. Lying on the couch may seem like an immediately appealing option, but going to the gym instead may be better for one's long-term health and well-being. More broadly, decision makers such as animals foraging for food, investors seeking returns, and pilots controlling aircrafts must consider how their current decisions will influence their future standing.

The question regarding how humans and other animals handle trade-offs between the immediate and delayed utility of each choice encompasses a growing body of research (Herrnstein, 1991; Herrnstein & Prelec, 1991; Loewenstein, 1987; Neth, Sims, & Gray, 2006; Tunney & Shanks, 2002; Worthy, Otto, & Maddox, 2012). Interestingly, most work has concluded that human choice is governed by a myopic tendency toward selecting alternatives with better immediate reward rather than alternatives with better delayed reward, a phenomena referred to as *melioration* (Herrnstein & Prelec, 1991). It is worth noting, however, that much of this work has been carried out with decision-making tasks that have utilized a gains reward structure. For example, participants often have to maximize points, money, or some other form of reward gained by repeatedly selecting from more than one option. However, many decision-making situations require people to minimize losses, punishments, or negative outcomes. The present work seeks to examine how people manage the trade-off between the immediate and delayed consequences of their actions in situations where they are attempting to maximize gains or minimize losses. There is extensive evidence that losses are viewed differently than equivalent gains during decision making (Abdellaoui, Bleichrodt, & Paraschiv, 2007; Gehring & Willoughby, 2002; Hardie, Johnson, & Fader, 1993; Kahneman, Knetsch, & Thaler, 1990; Novemsky & Kahneman, 2005; Rutledge & Glimcher, 2009; Sokol-Hessner et al., 2009; Tom, Fox, Trepel, & Poldrack, 2007). Accordingly, it is reasonable that humans may demonstrate distinct behavior in a losses reward environment compared with a gains reward environment.

One important goal of the current research is to examine how people handle the trade-off between the immediate and delayed consequences of their choices when attempting to minimize losses versus maximize gains. To do this, we employ a choice history-dependent decision-making paradigm that has been used extensively in prior work to examine how people juxtapose the immediate and delayed benefits of each option during decision making (e.g., Byrne & Worthy, 2013; Gureckis & Love, 2009; Otto & Love, 2010; Worthy, Gorlick, Pacheco, Schnyer, & Maddox, 2011; Worthy et al., 2012). In these tasks, one of the options, the *increasing* option, always gives a smaller immediate reward but causes future rewards for both options to increase. In contrast, the other option, the *decreasing* option always yields a larger immediate reward but causes future rewards for both options to decrease. We designed the reward structure for the task in Experiment 1 so that losses in the losses reward structure

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were comparable with gains in the gains reward structure. Therefore, Experiment 1 was designed to examine whether decision-makers in a losses reward environment would attend to the delayed consequences of their actions more compared with those in a gains reward environment. In addition, we also examined whether individual differences in self-control would moderate the effect of reward environment. In the following sections, we develop the theoretical background that motivated our experiments along with our hypotheses. We first present our predictions regarding decisions when attempting to maximize gains versus minimize losses, drawing upon evidence for loss aversion, especially work that has examined how losses influence intertemporal choice. Next, we turn to the role of emotion underlying loss aversion and how trait self-control influences emotion when making decisions that involve losses. We then briefly review work that has examined decision making from experience and finalize our predictions before presenting the results from the two experiments that examine how self-control affects decision-making when attempting to maximize gains or minimize losses.

Loss aversion and intertemporal choice

Kahneman and Tversky (1979; Tversky & Kahneman, 1991) formalized the notion that losses loom larger than gains. In risky contexts, people typically reject gambles with a 50% chance to gain and a 50% chance to lose comparable amounts of money. People are unwilling to accept such a proposition unless the amount that could be gained is at least twice the amount that could be lost (Tversky & Kahneman, 1992). In riskless contexts, people tend to value an object more highly when they possess it than they would value the same object if they did not possess it (i.e., endowment effect; Thaler, 1980). Consistent with behavioral evidence for loss aversion, recent neuroeconomics findings have shown that losses elicit greater event-related brain potentials (Gehring & Willoughby, 2002), skin conductance responses (Sokol-Hessner et al., 2009), increased heart rate and pupil dilation (Hochman & Yechiam, 2011), and activation in several brain regions (ventral striatum, amygdala, medial prefrontal cortex; Rutledge & Glimcher, 2009) than equivalent gains. However, some studies have discovered some situations where behavioral loss aversion does not appear (Hochman & Yechiam, 2011; Koritzky & Yechiam, 2010; Novemsky & Kahneman, 2005; Yechiam & Ert, 2011; for a review, see Yechiam & Hochman, 2013), although other studies have found evidence for increased arousal following losses, relative to gains, even when there is no evidence for behavioral loss aversion (Gehring & Willoughby, 2002; Hochman, Glöckner, & Yechiam, 2010; Hochman & Yechiam, 2011; Yechiam & Telpaz, 2011). Together, although recent work suggests that behavioral loss aversion is not universal, there is an extensive body of work that suggests a distinct role for losses compared with gains.

Further, research on intertemporal choice has also shown that discounting rates for future outcomes are smaller for losses than for gains (Loewenstein, 1987; MacKeigan, Larson, Draugalis, Bootman, & Burns, 1993; Read, 2004; Thaler, 1981; for an exception, Shelley, 1994). For instance, Thaler (1981) asked participants to imagine that they incurred a traffic ticket that could be paid now or later (by three months, one year, or three years). The discount rates in these questions were much lower than that in the questions about comparable monetary gains. Indeed, in many studies, most participants prefer to incur losses immediately rather than delay them (MacKeigan et al., 1993; Yates & Watts, 1975). Conversely, these findings could be explained as evidence that people assign greater weights to delayed losses than comparable delayed gains (if they assign smaller weights to delayed losses, they would prefer to defer losses.) As a consequence, decision makers probably would be better able to attenuate the tendency to be guided by immediate consequences in a losses reward environment relative to a gains reward environment. Moreover, a more recent paper that also included a choice history-dependent component like the one we employ in the present work found that managers tended to select a program that reduced future losses more than one that increased future gains (Chuang & Kung, 2006).

Emotion, loss aversion and self-control

As shown in the preceding section, the notion that losses loom larger than gains has been supported by extensive evidence. But what drives loss aversion? Camerer (2005) argued that it is often an emotional reaction of fear. Indeed, Rutledge and Glimcher (2009) found increased activation in amygdala, a limbic structure sensitive to emotionally arousing stimuli (LeDoux, 2000; Morris et al., 1996; Whalen et al., 1998), in response to losses relative to gains of equal magnitude. The connection between emotion and loss aversion is further supported by a study in which patients with damage to amygdala showed a reduction in loss aversion compared with matched controls (De Martino, Camerer, & Adolphs, 2010). These findings are also consistent with the work that has found heightened autonomic responses for losses than for equivalent gains (Hochman & Yechiam, 2011; Sokol-Hessner et al., 2009). Further, the endowment effect appears to increase with affective enrichment of consumer goods (e.g., music CDs vs. computer disks; Dhar & Wertenbroch, 2000) and more generally with emotional attachment to goods ,which suggests an emotional element of loss aversion. In short, there is an accumulating body of work that suggests that loss aversion is driven by an emotional fear of experiencing losses. In the current context, losses may cause emotional aversiveness, which is in turn responsible for one's increased sensitivity to future outcomes of their choices.

Self-control is generally defined as the capacity for altering one's dominant response tendencies (Bandura, 1989; Metcalfe & Mischel, 1999; Vohs & Baumeister, 2004). More specifically and more relevant to the present work, Metcalfe and Mischel (1999) theorized that self-control is the ability to inhibit impulsive responses processed in a hot (vs. cool) system, which is the basis of emotionality, fears as well as passions. Self-control has also been empirically linked to emotion regulation in several previous studies. Behaviorally, high trait self-control predicts reduced death anxiety and better psychological adjustment (Gailliot, Schmeichel, & Baumeister, 2006; Tangney, Baumeister, & Boone, 2004). In addition, on the basis of a large body of work in

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neuroscience, Heatherton and Wagner postulated a model of top-down regulation of the amygdala, traditionally associated with emotion (LeDoux, 2000; Morris et al., 1996; Whalen et al., 1998), by prefrontal cortex (PFC) that is widely considered a neural structure that mediates self-control (Hare, Camerer, & Rangel, 2009; Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007). This suggests that self-control may play a pivotal role in controlling emotion. Taken together, high self-control individuals may be more capable of inhibiting undesirable affective reactions than low self-control individuals. Linking this to our current research, we predict that participants with high trait self-control will be more likely to resist emotional aversiveness to losses and will behave more similarly regardless of whether rewards are presented in gains or losses frames, relative to participants with low trait self-control.

Description–experience gap

The tasks we used involve decision-making from experience and under uncertainty where the outcomes of each choice are initially unknown and must be learned from experience, rather than decision-making from description where the immediate and delayed consequences of each outcome are explicitly stated before each decision is made. A growing body of research has shown a gap between the two information formats (i.e., experience-based vs. description-based; Barron & Erev, 2003; Camilleri & Newell, 2011; Hau, Pleskac, & Hertwig, 2010; Hau, Pleskac, Kiefer, & Hertwig, 2008; Hertwig, Barron, Weber, & Erev, 2004; Hertwig & Erev, 2009; Rakow & Newell, 2010). For example, one main gap is that people tend to overestimate rare events when information is from description but underestimate them when from experience (for a review, see Hertwig & Erev, 2009).

In research on decision from experience, two main experimental paradigms have been used: sampling and feedback paradigms. In the sampling paradigm, participants freely sample, without cost, as often as they wish before a single consequential choice (e.g., Hertwig et al., 2004). In the feedback paradigm, participants select from alternatives for a fixed number of trials and receive immediate feedback about chosen (partial feedback) or chosen and foregone (full feedback) payoffs (e.g., Barron & Erev, 2003). Despite the procedural differences, the two paradigms produce largely consistent patterns of choice, underweighting rare events, as compared with decision from description (e.g., Erev et al., 2010; Hertwig et al., 2004). Critically, recent studies suggest that in the partial-feedback paradigm, people are more likely to demonstrate risk averse behavior because they tend to avoid uncertain alternatives with poor past outcomes, which would be present more for the risky option (Denrell, 2007; Grosskopf, Erev, & Yechiam, 2006; Yechiam & Busemeyer, 2006). In contrast, feedback on foregone payoffs can cause decision makers to be risk seeking. The tasks used in the current research constitute a form of a partial feedback paradigm. Thus, we predicted that participants would be generally risk-averse in this task. More importantly, however, we expect that the losses versus gains domains would moderate participants' choices. Although our tasks involve decision making under uncertainty rather than decision making under risk, the decreasing option in the tasks we present below could be viewed as being less risky and the increasing option more risky because the decreasing option provides larger benefits on every trial, whereas the benefit of selecting the increasing option comes in the future. On the basis of this, we predicted that participants would select the increasing option more often in the losses condition than in the gains condition.

Overview of the present research

In the present work, we present two studies that examine (1) whether participants will be more responsive to the immediate consequences of their actions when attempting to maximize gains than when attempting to minimize losses and (2) how self-control moderates such an effect. We use the Self-Control Scale (Tangney et al., 2004), in which participants answer questions regarding trait self-control to distinguish individuals who are low and high in self-control (e.g., I do certain things that are bad for me, if they are fun; I am able to work effectively toward my long-term goals [reverse scored]). In both experiments, participants performed a choice history-dependent decision-making task in either a gains domain, where they attempted to maximize points gained, or a losses domain, where they attempted to minimize points lost. As stated above, in Experiment 1, the long-term expected value for both options was the same and thus the task has no optimal choice because repeatedly selecting either option would lead to roughly the same cumulative reward. We predicted that participants would select the increasing option that yielded larger delayed utilities more often when attempting to minimize losses than when attempting to maximize gains, because losses would cause participants to give greater weight to future consequences. We predicted that this effect of reward environment would be more robust for low self-control participants than high self-control participants. In Experiment 2, we examined whether low self-control individuals would still show a more robust effect of losses, relative to high self-control participants, even when the decreasing option providing larger immediate benefits was the optimal choice.

EXPERIMENT 1

Method

Participants

A total of 124 undergraduates (52 male) recruited from an introductory psychology course at Texas A&M University participated in the experiment in exchange for course credit. Participants were randomly assigned to either the gain-maximization or loss-minimization conditions. Three participants were excluded because they did not complete the experiment because of computer failure. There were 62 participants in the gain-maximization condition and 59 participants in the loss-minimization condition who were included in the final data set.

Materials and procedures

Participants performed the experiment on PCs using Psychtoolbox for MATLAB (version 2.5). They were first

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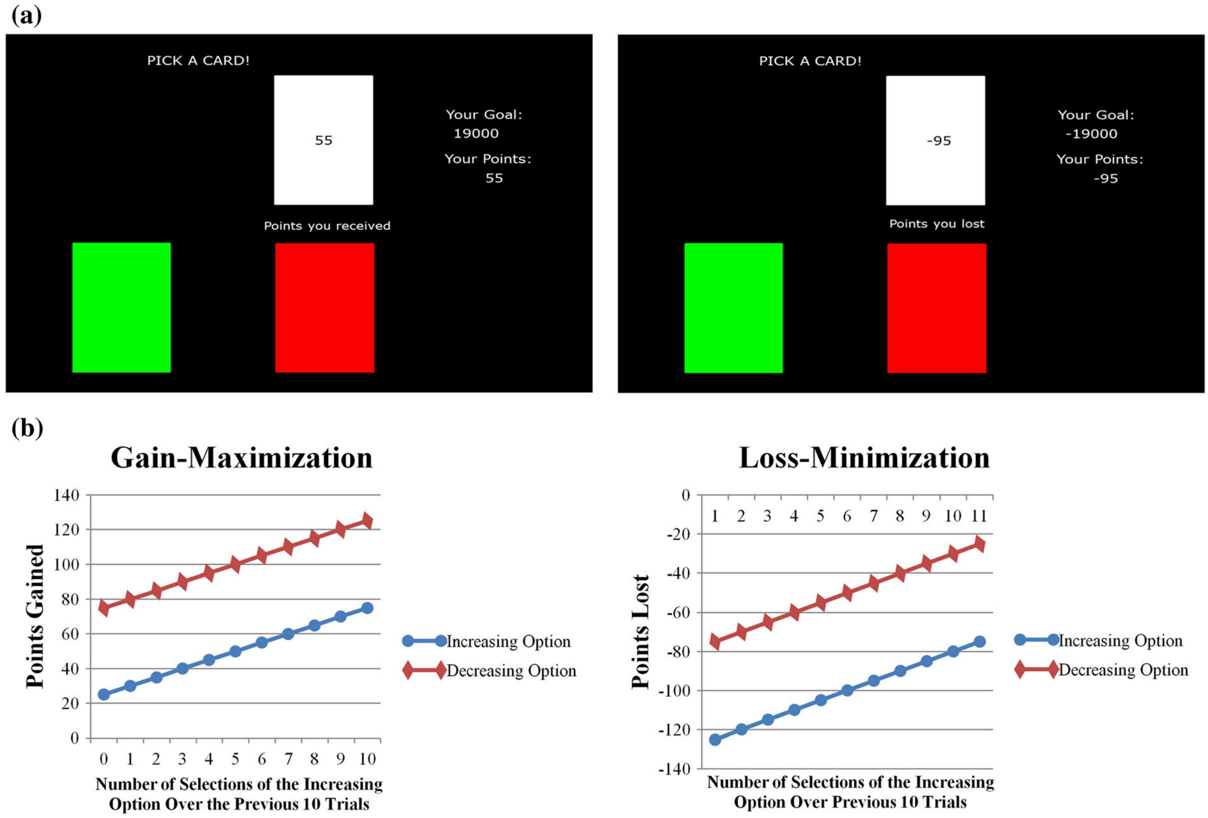

Figure 1. (a) Sample screenshot from the gain-maximization (left panel) and loss-minimization conditions (right panel). Participants performed a total of 250 trials in each condition. (b) Reward structure for the gain-maximization (left panel) and loss-minimization conditions (right panel). The value of the reward associated with each option is shown as a function of the number of times participants selected the increasing option during the previous 10 trials. The expected value for the two options in a given condition was equivalent over the long-term.

administered the Self-Control Scale (brief version) that consists of 13 items (Tangney et al., 2004). Higher scores on this measure indicated higher self-control ability. The Self-Control Scale has been demonstrated to have high internal consistency (alpha = .85), test–retest reliability (i.e., .89) on large samples of college students, and test validity with both self-reported measures and laboratory tests (Schmeichel & Zell, 2007; Tangney et al., 2004). Following the questionnaire, participants were randomly assigned to either the gain-maximization condition or the loss-minimization condition.

Figure 1(a) (left panel) shows a sample screenshot from a trial under the gain-maximization condition of the decision-making task. Participants were asked to pick a card from two decks of cards with the goal of gaining as many points as possible. They were provided no prior information about points gained from each selection. Participants in the gain-maximization condition started with zero points and gained points on each draw for a total of 250 trials.

Figure 1b (left panel) and Table 1 display the reward structure for the gain-maximization condition. Points gained on each draw were a function[1] of the number of times participants selected the increasing option during the previous 10 trials. Thus, there was a "moving window" that tracked the number of times the increasing option had been selected over the previous 10 trials. All participants began the experiment at the midpoint (5) on the x-axis. The decreasing option always yielded more points than the increasing option for any given trial. For example, at the midpoint along the x-axis, selecting the decreasing option (corresponding to the upper-diagonal line in Figure 1b and in the third column in Table 1) would produce 100 points, whereas selecting the increasing option (corresponding to the lower-diagonal line in Figure 1b and in the second column in Table 1) would generate only 50 points. Thus, the decreasing option seems attractive in the short-term. However, each time the decreasing option is selected, the expected output of both options is lowered on future trials. In contrast, selections of the increasing option affect future rewards in the opposite way. When this option is selected, the outcome of both options is increased on future trials. One important thing to note is that the decreasing and increasing effects of the two respective options are not only shown on the very next trial but also influence the next 10 trials because the state of the reward system depends on the number of selections of the increasing option selected over the previous 10 trials.

The maximum value for the increasing option was equivalent to the minimum value for the decreasing option (both 75 points). Therefore, the two options had roughly equivalent expected value over the long-term (we say "roughly" because there was a small start-of-game effect where the decreasing option was better than the increasing option in the first few

[1]In the gain-maximization condition, the reward for selecting the increasing option is equal to $25 + 5h$ and the reward for selecting the decreasing option is equal to $75 + 5h$, where h is the number of increasing option selections in the last 10 trials. In the loss minimization condition, the loss for selecting the increasing option is equal to $25 + 5h - 150$ and the loss for selecting the decreasing option is equal to $75 + 5h - 150$, where h is the number of increasing option selections in the last 10 trials.

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Table 1. The reward structure of the gain maximization condition. Selections of the increasing option transition the state of the reward system upward. In contrast, selections of the decreasing option move the state of the reward system downward

Number of Selections of the Increasing Option Over the Previous 10 Trials (State of the Reward System)		Points Gained for the Increasing Option	Points Gained for the Decreasing Option
10		75	125
9	↑ Selection of	70	120
8	the Increasing	65	115
7	option	60	110
6		55	105
5		50	100
4	Selection of	45	95
3	the Decreasing	40	90
2	option ↓	35	85
1		30	80
0		25	75

trials). In other words, this task was designed so that it had no overall optimal option, which is similar to classic description-based tasks (e.g., the Asian disease problem) where participants must pick from safe versus risky options with equivalent expected values. The goal for the gains task was set at 19 000 points. Because the two options had equivalent long-term value, this goal was equal to the number of points participants would earn by the end of the task regardless of which option they picked. The goal was to motivate participants to engage in the task.

Figure 1a (right panel) shows a sample screenshot from a trial under the loss-minimization condition of the decision-making task. Participants were asked to pick a card from one of two decks with the goal of losing as few points as possible. They started with zero points and lost points on each draw. They were asked to minimize losses with the goal of not losing more than 19 000 points, which was roughly equivalent to what participants would lose from selecting either of the two options over 250 trials. Like the gain-maximization condition, there was no overall optimal option.

Figure 1b (right panel) displays the reward structure for the loss-minimization condition. The losses in the loss-minimization condition were derived directly from the gains in the gain-maximization condition by subtracting 150 points from each reward value possibly gained in the gain-maximization condition. For example, if the increasing option was selected five times over the previous 10 trials, 100 points would be lost by a draw from the increasing deck, whereas 50 points would be gained by a draw of the increasing deck of cards under the gain-maximization condition. Therefore, the gain-maximization condition and loss-minimization condition had corresponding reward structures, and there were equivalent long-term expected values for each option within a given reward structure condition. The critical difference between the two conditions was whether payoffs were presented in a gain versus loss frame.

Results

We first performed a median-split ($Mdn = 42$) across the gain-maximization and loss-minimization conditions to assign participants to the high trait self-control group ($N = 65$) or the low trait self-control group ($N = 56$). Next, we divided the data into early (Trials 1–125) and late phases (Trials 126–250) of the task and examined behavior during each phase by computing the proportion of times participants selected the increasing option. We first conducted a 2 (self-control) × 2 (reward structure) × 2 (phase) repeated measures ANOVA on participants' response times. There was a significant main effect of phase, $F(1, 117) = 5.80$, $p = .02$, partial $\eta^2 = .047$. Participants had slightly faster response times in the late phase ($M = .52$, $SD = .34$) than in the early phase ($M = .59$, $SD = .22$), but no other significant effects were found.

Next, we then conducted a 2 (self-control: high vs. low) × 2 (reward structure: gain-maximization vs. loss-minimization) × 2 (phase: early vs. late) repeated measures ANOVA on the proportion of increasing option selections. Figure 2 displays the proportion of increasing options selected in each condition. There were significant main effects of reward structure, $F(1, 117) = 7.11$, $p < .01$, partial $\eta^2 = .057$, and phase, $F(1, 117) = 12.20$, $p < .01$, partial $\eta^2 = .094$. Participants selected the increasing option more often in the loss-minimization condition ($M = .50$, $SD = .22$) than in the gain-maximization condition ($M = .40$, $SD = .22$). Participants also selected the increasing option more often in the late phase ($M = .48$, $SD = .28$) than in the early phase ($M = .41$, $SD = .22$). There was also a significant Self-control × Reward Structure × Phase interaction, $F(1, 117) = 9.11$, $p < .01$, partial $\eta^2 = .072$.

To determine the locus of the three-way interaction, we first examined the simple two-way interaction between self-control and reward structure within each phase. Within the early phase, there was a significant main effect of reward structure, $F(1, 117) = 5.38$, $p = .02$, partial $\eta^2 = .044$, but the

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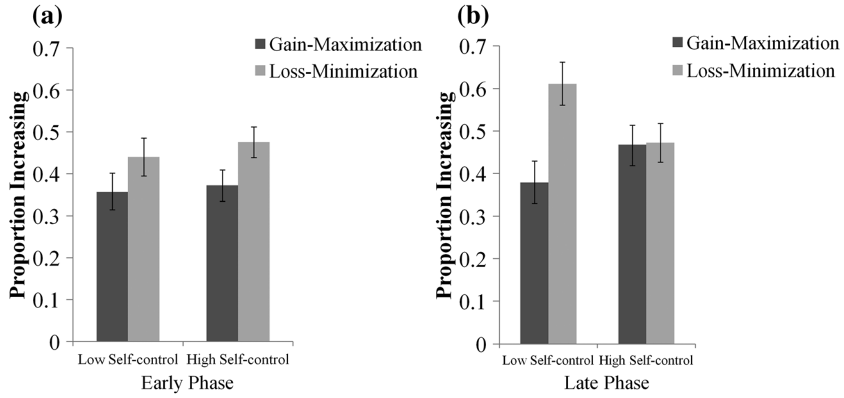

Figure 2. Proportion of the increasing option selections for participants in each condition of Experiment 1. Standard error bars are included

interaction was not significant, $F(1, 117) < 1$, $p = .81$, partial $\eta^2 < .001$. This suggests that performing the task with a losses reward structure caused participants to select the increasing option, which yielded larger delayed benefits, more often than the gains reward structure, but self-control did not moderate this effect. In contrast, within the late phase, there was a main effect of reward structure, $F(1, 117) = 5.90$, $p = .02$, partial $\eta^2 = .048$, and a significant interaction, $F(1, 117) = 5.48$, $p = .02$, partial $\eta^2 = .045$. To determine the locus of the interaction, we performed pairwise comparisons within each self-control group. Within the low self-control group there was a significant effect of reward structure, $t(54) = -3.30$, $p < .01$. Low self-control participants selected the increasing option significantly more often when attempting to minimize losses ($M = .61$, $SD = .26$), than when attempting to maximize gains ($M = .37$, $SD = .27$). In contrast, there was no effect of reward structure within the high self-control group, $t(63) = -.06$, $p = .95$.

Further, we tested whether the proportion of increasing options selected was significantly different from .5, which would be expected from chance, within each reward structure condition for participants in the low self-control group during the late task phase. Low self-control participants selected the increasing option significantly more often than would be expected by chance when attempting to minimize losses, $t(27) = 2.27$, $p = .03$. In contrast, these participants selected the increasing option significantly less often than would be expected by chance when attempting to maximize gains, $t(27) = -2.40$, $p = .02$.

Mixed-effects logistic regression analysis

In addition to examining self-control by performing a median split in the ANOVA analysis, we also conducted a mixed-effects linear model analysis (Pinheiro & Bates, 2000), examining trial-by-trial selections to the increasing option (a binary variable) as a function of self-control and reward structure, taking intercepts and slopes for the effect of phase (the only within-subject variable) as random effects over subjects.

Critically, self-control was treated as a continuously valued predictor variable, in contrast to the ANOVAs reported previously. The coefficient estimates are reported in Table 2. Importantly, we found a significantly negative effect of reward structure, positive effect of phase, and positive three-way interaction of self-control, reward structure and phase (Table 2 and Figure 2), which was qualitatively in line with the results pattern shown in the ANOVA analysis where self-control was dichotomized on the basis of a media split.

Further, to test whether self-control or its interaction with reward structure and phase would influence switching behavior, we conducted the same analysis for response switches (i.e., selections were different on Trial $t-1$ from Trial t; a binary variable) on each trial. We only found a significant (and negative) main effect of phase, indicating that participants switched more often in the first phase of the task. This decreased tendency to switch over time is intuitive, as participants tend to explore the reward environment more in the early phase than in the late phase.

Discussion

In Experiment 1, participants were more prone to select the increasing option, which yielded larger benefits on future trials, in the loss-minimization condition than in the gain-maximization condition. Put another way, people were more eager to try to reduce losses incurred on future trials than to increase gains received on future trials even if it meant temporarily receiving larger immediate losses. It is reasonable that the losses reward structure increased participants' sensitivity to delayed consequences and in turn rendered them more eager to reduce losses on future trials by selecting the increasing option, compared with the gains reward structure.

We also found that self-control moderated the effect of losses during the late phase of the task by enhancing the effect for low self-control participants while attenuating it for high self-control participants. Furthermore, within the low self-control group, we found a choice reversal effect wherein participants selected the increasing option more often than expected from chance when attempting to minimize losses but selected the increasing option less often than expected from chance when attempting to maximize gains during the late phase of the task. Intuitively, participants with low self-control might prefer the decreasing option that provides immediate higher rewards or fewer losses. This is indeed the case for participants performing in the gain-maximization condition. However, the results are consistent with our hypothesis that losses would evoke participants' affective aversiveness and lead them to reduce delayed losses even if it temporarily brought larger immediate losses.

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Table 2. Regression coefficients, indicating the influence of reward structure, self-control, and phase on increasing option selection or response switch

		Coefficient	Estimate (SE)	*p*-value
Experiment 1	Increasing option selection	(Intercept)	-.31 (.12)	.01*
		Reward structure	-.31 (.12)	.01*
		Self-control	-.01 (.12)	.97
		Phase	.18 (.07)	<.01*
		Reward structure × self-control	.13 (.12)	.30
		Reward structure × phase	-.09 (.07)	.18
		Self-control × phase	-.05 (.07)	.43
		Reward structure × self-control × phase	.14 (.07)	.03*
	Response switch	(Intercept)	−1.38 (.10)	<.01*
		Reward structure	.10 (.10)	.31
		Self-control	.10 (.10)	.33
		Phase	-.19 (.06)	<.01*
		Reward structure × self-control	-.16 (.10)	.10
		Reward structure × phase	.01 (.06)	.86
		Self-control × phase	-.02 (.06)	.76
		Reward structure × self-control × phase	-.09 (.06)	.09
Experiment 2	Increasing option selection	(Intercept)	-.65 (.11)	<.01*
		Reward structure	.02 (.11)	.86
		Self-control	-.15 (.11)	.20
		Phase	.05 (.06)	.38
		Reward structure × self-control	.27 (.11)	.02*
		Reward structure × phase	-.12 (.06)	.04*
		Self-control × phase	.05 (.06)	.38
		Reward structure × self-control × phase	-.01 (.06)	.81
	Response switch	(Intercept)	-1.46 (.09)	<.01*
		Reward structure	.34 (.09)	<.01*
		Self-control	-.12 (.09)	.18
		Phase	-.14 (.05)	<.01*
		Reward structure × self-control	-.04 (.09)	.62
		Reward structure × phase	.01 (.05)	.79
		Self-control × phase	-.02 (.05)	.70
		Reward structure × self-control × phase	<.01 (.05)	.93

*Denotes significance at the level .05 level.

EXPERIMENT 2

Experiment 2 sought to conceptually replicate and extend the findings from Experiment 1. In Experiment 2, we modified the reward structure used in Experiment 1 so that the increasing option became the globally suboptimal option (Otto, Markman, & Love, 2012). Selecting the decreasing option allowed participants to gain 90 more points (in the gain-minimization condition) or to lose 90 fewer points (in the loss-minimization condition) on each trial at all states than they would have received if selecting the increasing option. We predicted that the immediate reward differences would be very noticeable to participants and might eliminate the effect of losses found in Experiment 1 because participants would learn that the decreasing option was optimal and select this option more often in both the gains and losses reward structure conditions. However, we also predicted that whereas high self-control participants may be indifferent to the manipulation of the reward structure when one option has a superior expected value, low self-control participants would still select the suboptimal increasing option significantly more often when attempting to minimize losses than when attempting to maximize gains, because of eagerness to reduce losses on future trials.

Method

Participants

A total of 138 undergraduates (62 male) recruited from an introductory psychology course at Texas A&M University participated in the experiment in exchange for course credit. Participants were randomly assigned to either the gain-maximization or loss-minimization conditions. There were 69 participants in each condition.

Materials and procedures

The materials and procedures in Experiment 2 were identical to those in Experiment 1 except for the change in the reward structure for the task. Participants were first administered the Self-Control Scale (Tangney et al., 2004). Following the questionnaire, participants were assigned to either the gain-maximization condition or the loss-minimization condition.

Figure 3 left and right panels display the reward structures for the gain-maximization condition and the loss-minimization condition, respectively. These reward structures both had an end-state separation of 40 points. More precisely, the minimum reward for the decreasing option was 40 points larger than the maximum reward for the increasing option in both gain-maximization and loss-minimization conditions. The goal was set at 22 000 points

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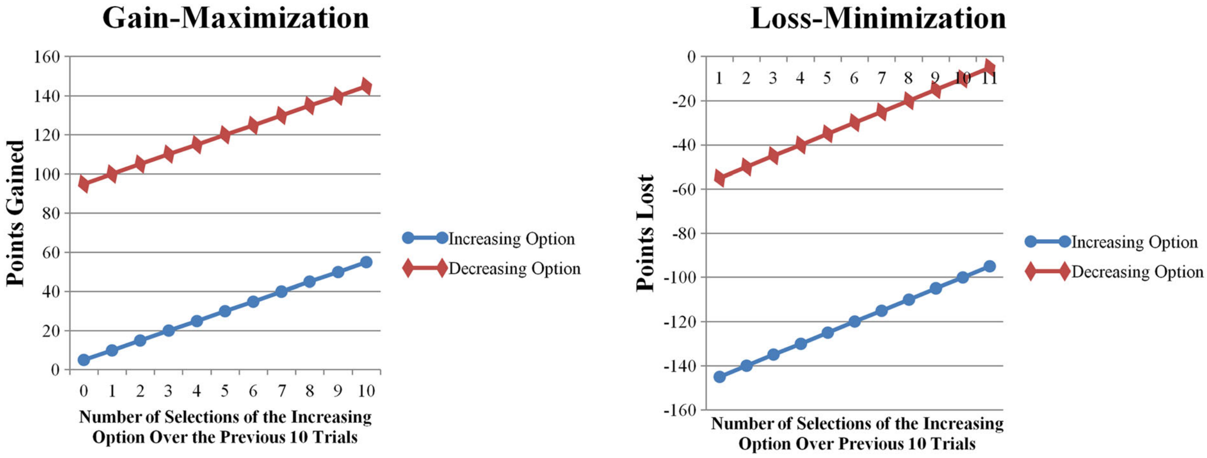

Figure 3. Reward structure for the gain-maximization (left panel) and loss-minimization conditions (right panel). The value of the reward associated with each option is shown as a function of the number of times participants selected the increasing option during the previous 10 trials. The optimal strategy in both conditions is to repeatedly select the decreasing option

in the gain-maximizations condition and at −15 750 points in the loss-minimization condition, which corresponded to selecting the optimal option (the decreasing option) on roughly 80% of trials.

Results

As with Experiment 1, we first performed a median-split (*Mdn* = 45) across the gain-maximization and loss-minimization conditions to assign participants to high self-control (*N* = 71) and low self-control groups (*N* = 67) and divided the data into early (Trials 1–125) and late phases (Trials 126–250). We first conducted a 2 (self-control) × 2 (reward structure) × 2 (phase) repeated measures ANOVA on the reaction time, but no significant effects were found. Then, we conducted a 2 (self-control) × 2 (reward structure) × 2 (phase) repeated measures ANOVA on the proportion of increasing option selections. Figure 4 shows the proportion of increasing option selections in each condition. The main effects of reward structure, phase, and self-control were all non-significant, $F(1, 134) < 1$, $p = .70$, partial $\eta^2 = .001$; $F(1, 134) = 2.26$, $p = .14$, partial $\eta^2 = .017$; $F(1, 134) = 2.13$, $p = .15$, partial $\eta^2 = .016$, respectively. There was a significant Self-control × Reward Structure interaction for the full sample, $F(1, 134) = 6.47$, $p = .01$, partial $\eta^2 = .046$. No other interactions reached significance. To determine the locus of the interaction, we conducted follow-up *t*-tests within each self-control group. Within the low self-control group, participants selected the increasing option more often when attempting to minimize losses ($M = .47$, $SD = .22$) than when attempting to maximize gains ($M = .36$, $SD = .21$), $t(65) = -2.05$, $p = .04$. In contrast, within the high self-control group, there was no effect of reward structure (Gains, $M = .40$, $SD = .19$; Losses, $M = .32$, $SD = .24$).

Mixed-effects logistic regression analysis

Following Experiment 1, we conducted a mixed-effects linear model analysis where self-control was treated as a continuously valued predictor for increasing option selection and response switches on each trial. Detailed results are presented in Table 2. Critically, when examining increasing option selections as the outcome variable, we found a significantly positive interaction between reward structure and self-control (Table 2 and Figure 4), which corroborates the ANOVA results.

Examining response switches as the outcome variable, there was a significant effect of phase and reward structure. Like in Experiment 1, we discovered more frequent response switching in the first phase than in the second phase. Further, participants in the gains condition switched more frequently than those in the losses condition, suggesting participants performed in the losses domain might have employed a relatively comprehensive strategy (Hills & Hertwig, 2010) to explore the reward environment compared with those in the gains domain.

Discussion

In Experiment 2, we did not observe an overall effect that participants selected the increasing option more often when attempting to minimize losses than when attempting to maximize gains in the task where the increasing option was suboptimal.

We nonetheless found that self-control affected how participants behaved when attempting to maximize gains versus minimize losses. Participants with low self-control were affected by losses in a similar way as Experiment 1; however, participants with high self-control were unaffected by the reward structure. More specifically, low self-control individuals selected the increasing option more often when attempting to minimize losses than when attempting to maximize gains, whereas high self-control participants selected each option equivalently regardless of how reward outcomes were framed. This suggests that the effect of losses whereby decision makers are eager to reduce delayed losses in choice history-dependent decision-making is robust in low self-control individuals even when the increasing option is suboptimal.

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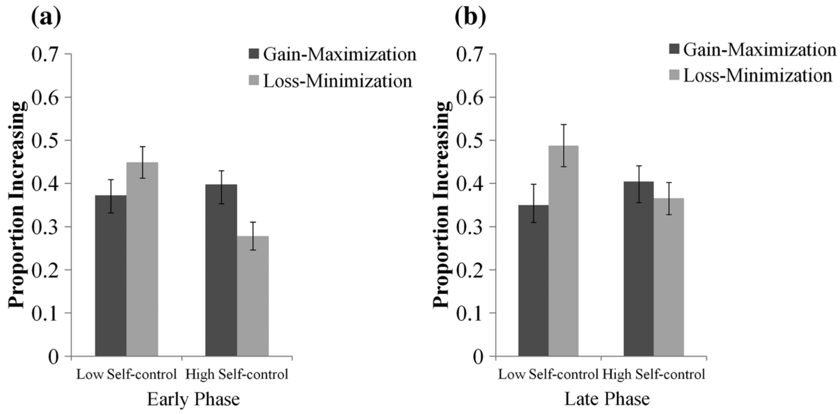

Figure 4. Proportion of the increasing option selections for participants in each condition of Experiment 2. Standard error bars are included

GENERAL DISCUSSION

The purpose of this investigation was to examine how people manage a trade-off between immediate consequences and delayed consequences of their decisions when attempting to minimize losses versus when attempting to maximize gains and whether self-control would moderate such an effect. The results from the two experiments support two major conclusions. First, the results suggest that participants are more prone to reduce losses on future trials when attempting to minimize losses than to increase gains on future trials when attempting to maximize gains in a history-dependent decision-making task. This effect of losses was only present when the two options had equivalent long-term expected values (Experiment1).

A wide range of evidence has demonstrated that losses have enhanced psychological and neural effects relative to comparable gains (e.g., Gehring & Willoughby, 2002; Rutledge & Glimcher, 2009; Tversky & Kahneman, 1992). In the present research, the loss-minimization and gain-maximization conditions had corresponding reward structures, but participants displayed different decision-making behavior when attempting to maximize gains versus minimize losses. The current findings add evidence to the notion that losses loom larger than gains (Tversky & Kahneman, 1991). It might be worth noting that loss aversion could mean preferring to reduce immediate losses over accepting immediate gains by selecting the decreasing option *more* in the losses condition than in the gains condition, which would be counter to our current findings. We did not find support for such a hypothesis. Instead, our results are consistent with the intertemporal choice literature that suggests delayed losses are discounted less (or even negative discounting) than delayed gains (e.g., Loewenstein, 1987; MacKeigan et al., 1993; for an exception, Shelley, 1994). We found that participants were more willing to reduce losses on future trials by selecting the increasing option when attempting to minimize losses than to increase gains on future trials when attempting to maximize gains, and this was especially pronounced in low self-control individuals. It suggests that participants weighted future losses more than equivalent future gains.

Unlike previous studies on intertemporal choice whereby the delivery schedule and magnitudes of rewards associated with each alternative are explicitly presented to participants, the action-contingencies in the present research were unbeknownst to decision makers. Thus, participants are not only decision-makers but also learners in a novel decision-making context. It is worth noting that a growing body of research indicates that cognitive processes and overt behavior rely on whether information is acquired by description of events or through personal experience (e.g., Hau et al., 2008; Hertwig et al., 2004). However, the current research where participants needed to learn contingencies from experience are in line with previous intertemporal choice studies using traditional description-based paradigms. Both the current work and the prior work demonstrate the increased salience of delayed consequences when they are framed in terms of losses rather than gains, suggesting a “special” psychological role of losses in decision-making. Also, it is worth noting the differences between the time intervals used to distinguish immediate from future reward in the current study from those in description-based tasks used in prior work. Traditional description-based decision-making tasks have used relatively long intervals such as one week, one month, or even one year. However, in our experience-based task, current choices affected rewards over the next 10 trials, which is a relatively short interval. Thus, although there are some discrepancies between our study and other paradigms that have been used to examine discounting of gains and losses, our results add to an extensive body of work that suggests that losses have smaller discount rates than gains.

Another line of work has focused on how people develop preferences over sequences of outcomes (for a review, see Loewenstein & Prelec, 1993). This work could provide an interesting alternative explanation to our results. These studies have generally found that people prefer improving sequences to declining sequences. For example, Loewenstein and Sicherman (1991) found that, all else being equal, most workers prefer an increasing wage profile to a declining or flat one. Although those studies did not predict different profiles in the gains versus losses domains, our results in Experiment 1 could be interpreted as evidence that participants preferred an increasing pattern more in the losses domain than in the gains domain when the two options have the equivalent long-term values. Importantly, Loewenstein and Prelec (1993) suggested that whether the objects of choice

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are perceived as single-outcome prospects or sequences determines whether impatience (delayed outcomes are valued less) or a preference for improvement dominates choices. The present research did not explicitly control this factor, but one possibility is that better learning of the reward structure would result in a higher probability of detecting the dependence of choices and perceiving the choices as sequences. Recent research on losses (Hochman et al., 2010; Hochman & Yechiam, 2011; for e review, see Yechiam & Hochman, 2013) discovered that losses enhance on-task attention and, therefore, increase sensitivity to reinforcement structure. From this view, participants in the losses condition would learn the reward structure better and with a higher probability to perceive the choices as sequences compared with participants in the gains condition. Consequently, participants might prefer the increasing option more in the losses condition than those in the gains condition.

The second major conclusion of the present paper is that trait self-control moderates the effect of losses. In the late phase of Experiment 1, participants with low trait self-control selected the increasing option, which yielded larger future benefits more often when attempting to minimize losses than when attempting to maximize gains, whereas participants with high self-control were unaffected by the manipulation of reward structure. This pattern of results was replicated in Experiment 2 where selecting the increasing option would lead to smaller cumulative gains or larger cumulative losses.

Given the association between loss aversion and emotion (Camerer, 2005; De Martino et al., 2010; Rutledge & Glimcher, 2009), it is reasonable that low self-control individuals experience more emotional aversiveness to losses than high self-control individuals because the former are less able to regulate the affective aversiveness elicited by losses than the latter. Low self-control individuals may consequently have stronger eagerness to minimize losses incurred on future trials than to maximize gains on future trials, whereas high self-control individuals exhibit similar choice behavior in the gain and loss domains. Moreover, losses might result in ego depletion and weakening of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998), which probably further facilitates the tendency. Overall, this is in accord with a previous work that has demonstrated that high self-control is associated with more rational choices (Frederick, 2005; Sütterlin, Herbert, Schmitt, Kübler, & Vögele, 2011). Indeed, Frederick (2005) found that individuals with greater ability to resist intuitively compelling responses were less sensitive to the manipulation of gains versus losses in questions that had certain and risky options (e.g., "Would you prefer $100 for sure or a 75% chance of $200," or "Would you prefer to lose $100 for sure or a 75% chance to lose $200) than those with lower such ability.

Furthermore, in Experiment 1, we found a choice reversal effect where participants with low self-control selected the increasing option more than expected from chance when attempting to minimize losses but less often than expected from chance when attempting to maximize gains. It is thus likely that low self-control participants focused more on future consequences in the losses reward structure but more on immediate consequences in the gains reward structure. This coincides with framing effects where decision makers are risk-averse when problems are positively framed and risk seeking when problems are negatively framed (Tversky & Kahneman, 1981).

In this sense, our findings suggest that human decision-making violates predictions from rational choice theory and that individuals with lower self-control are more likely to deviate from rational choice. Recently, a dual-process theory, which suggests that a combination of intuitive/heuristic and analytic/executive processes contributes to human decision making, was proposed to explain humans' "irrational decision-making" (Kahneman & Frederick, 2007; see also, Kahneman, 2011). As with several other dual-process models (Evans, 2008; Sloman, 1996), intuitive/heuristic (referred to as System 1) operations are typically rapid, automatic, parallel, effortless, and often emotionally charged. In contrast, analytic/executive (referred to as System 2) operations are slow, controlled, serial, and effortful. Kahneman (2011) proposed that heuristics operating in System 1 that dominates humans' decision behavior could cause irrational choices, although decisions derived from System 1 are effective in most situations.

From the perspective of the dual-process model, self-control as the capacity for altering one's dominant response tendencies may influence one's reliance on System 1 versus System 2 during decisions. It is possible that low self-control individuals make decisions based more on System 1, resulting in choice reversal as a function of reward structures (losses versus gains). In contrast, high self-control individuals could rely more on System 2 to make rational choices. Also, Kahneman and Frederick's dual-process model (2005) assumes that one important function of System 2 is to monitor and override erroneous responses generated by System 1. On the basis of this view, self-control could play a critical role in overriding heuristic-based choices from System 1 in order to make rational decisions on the basis of System 2.

Limitations and future directions

Although loss aversion has been widely linked to affective aversiveness, one thing to note is that we did not measure emotional activity directly during decision-making. Future research should incorporate physiological or neurobiological measures of affective reaction such as galvanic skin responses, heart rate, or activity in neural regions such as the amygdala, which have been implicated in emotion-based processing. Such work would be quite valuable in better identifying the affective role of losses.

In addition, we hasten to note that the connection between self-control and exertion of System 1 versus System 2 was not tested directly in the current research. Future research that experimentally manipulates self-control may help to better establish the causal relation between them. For example, according to the self-control literature, activation of high-level construals results in greater self-control than activation of low-level construals (Fujita, Trope, Liberman, & Levin-Sagi, 2006; Schmeichel & Vohs, 2009). Hence, it is possible that participants primed with high-level construals would be better able to make rational choices in situations that need exertion of System 2.

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CONCLUSION

The trade-off between immediate and delayed benefits is common and crucial in our daily life. We examined how people manage this trade-off when attempting to maximize gains versus attempting to minimize losses and how self-control moderates such an effect of losses. A dynamic decision-making task paradigm was employed. Our results imply that (1) decision makers are more eager to reduce delayed losses and to increase delayed gains and (2) this effect is especially pronounced in low self-control individuals.

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