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No Effect of Ego Depletion on Risk Taking

Lina Koppel ^{1,2}, David Andersson^{1,2}, Daniel Västfjäll^{1,2,3,4} & Gustav Tinghög ^{1,2,5}

We investigated the effect of ego depletion on risk taking. Specifically, we conducted three studies (total $n = 1,716$) to test the prediction that ego depletion results in decisions that are more strongly in line with prospect theory, i.e., that ego depletion reduces risk taking for gains, increases risk taking for losses, and increases loss aversion. Ego depletion was induced using two of the most common manipulations from previous literature: the letter 'e' task (Studies 1 and 3) and the Stroop task (Study 2). Risk taking was measured using a series of standard, incentivized economic decision-making tasks assessing risk preferences in the gain domain, risk preferences in the loss domain, and loss aversion. None of the studies revealed a significant effect of ego depletion on risk taking. Our findings cast further doubts about the ability of ego-depletion manipulations to affect actual behavior in experimental settings.

Self-control is a key factor for success in many areas of life, including financial behavior¹ and academic success². In this paper, we explore the effect of temporary depletion of one's self-control resources—the state known as ego depletion—on risk taking, a core component of everyday behavior and decision making. It is a common belief that inhibition of controlled (i.e., System 2) processing influences risk taking, yet results from previous studies are mixed and ego depletion as a phenomenon has been a topic of debate in recent years. We here report three studies investigating the prediction that ego depletion results in decisions that are more strongly in line with prospect theory, i.e., that ego depletion reduces risk taking for gains, increases risk taking for losses, and increases loss aversion. Study 1 reports data collected by our lab as part of the Hagger *et al.* multi-lab registered replication report (RRR) on the ego-depletion effect³. Study 2 extends those findings using a larger sample and a manipulation that has been shown to more effectively induce ego depletion. Study 3 further shows the robustness of our results in a high-powered online study.

According to dual-process theories, decisions are the result of an interaction between intuitive (System 1) and deliberative (System 2) processes^{4–8}. System 1 is commonly characterized as fast, automatic, and effortless, whereas System 2 is characterized as slow, controlled, and effortful. To study these processes, researchers typically use manipulations that inhibit System 2, thereby increasing reliance on System 1. Common manipulations include time pressure, cognitive load, and cognitive depletion (ego depletion), which is the approach used here.

System 1 gives rise to a number of automatic biases in everyday behavior and decision making. With regards to risk taking, System 1 is arguably reflected in the S-shaped value function of prospect theory⁸. That is, people tend to be risk averse for gains and risk taking for losses (known as the *reflection effect*) and more sensitive to losses relative to gains (known as *loss aversion*)⁹. Increasing reliance on System 1 should enhance these behavioral tendencies and make people less likely to make decisions that maximize expected value. In line with this prediction, previous studies have shown that time pressure (compared to time delay)¹⁰ and stress (compared to no stress)¹¹ reduce risk taking for gains and increase risk taking for losses, indicating that inhibiting System 2 leads to an increased reflection effect of prospect theory. Similar results have been found when comparing participants who score low on the Cognitive Reflection Test (CRT; which indicates that they rely more on System 1) to those who score high (who rely more on System 2)¹². Furthermore, under time pressure but not time delay, participants' risky choices are predicted by increased skin conductance levels, suggesting that time pressure increases reliance on affective (System 1) signals¹³. Although different types of System 1–System 2 manipulations are assumed to have similar effects on behavior, no previous study has explored whether inhibiting System 2 using ego depletion makes people behave more in line with prospect theory.

¹JEDI Lab, Division of Economics, Department of Management and Engineering, Linköping University, Linköping, Sweden. ²Center for Social and Affective Neuroscience, Department of Clinical and Experimental Medicine, Linköping University, Linköping, Sweden. ³Division of Psychology, Department of Behavioral Sciences and Learning, Linköping University, Linköping, Sweden. ⁴Decision Research, Eugene, OR, USA. ⁵The National Center for Priority Setting in Health Care, Department of Medical and Health Sciences, Linköping University, Linköping, Sweden. Correspondence and requests for materials should be addressed to G.T. (email: gustav.tinghog@liu.se)

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Ego depletion refers to the phenomenon that exerting self-control in one task reduces performance in a second task that also requires self-control. For example, participants who have resisted the temptation to eat chocolate give up sooner on a difficult problem-solving task, compared to participants who have not¹⁴. Ego depletion is arguably a suitable manipulation of System 1–System 2 processing, because System 2 involves control and effort and relies on self-regulatory resources. Depleting or reducing the self-regulatory resources should inhibit System 2 and make decisions more intuitive and System 1 based. To induce ego depletion, we used two of the most common tasks from previous literature: the letter ‘e’ task (Studies 1 and 3) and the Stroop task (Study 2). These tasks have been recommended in recent meta-analyses because of their effectiveness in inducing a state of ego depletion^{15–17}. Using an appropriate depletion task was especially important given that ego depletion has been a topic of much debate in recent years. We also include a large sample of participants. Thus, we give ego depletion the best possible chance to produce an effect.

Although no previous study has tested the prediction that ego depletion results in more prospect-theory-like behavior, previous studies have investigated the effect of ego depletion on risk taking more generally. Results from these studies are mixed (see Supplementary Table S1). Most published studies have suggested that ego depletion increases risk taking^{18–23}. Specifically, ego depletion has been shown to increase self-reported sensation seeking and risk taking¹⁹ as well as actual risk taking in both incentivized^{20,21} and unincentivized^{18–20,22,23} tasks. However, some studies have found the opposite effect: ego depletion reduces risk taking^{24–26}. Yet other studies have found that the effect of ego depletion on risk taking depends on factors such as trait self-control²⁷ (but see two other studies that found no significant interaction between state and trait self-control^{20,28}), the amount of effort required in the risk task²⁹, and using intuition to guide decision making³⁰. Given these inconsistencies, it is perhaps unsurprising that a recent high-powered ($n = 308$) study failed to find any effect of ego depletion on risk taking in an incentivized multiple choice list task²⁸.

In sum, previous studies on the effect of ego depletion on risk taking have used a variety of manipulations of ego depletion and a variety of measures of risk taking, and sample sizes have generally been small (with one exception²⁸). Therefore, the literature might suffer from some of the same potential issues as the ego depletion literature at large, including small-study bias^{31–33}. Furthermore, with few exceptions^{21,28}, previous studies have not used risk-taking measures that are specifically designed to inform theoretical models of economic decision making. Most importantly, no study has distinguished between gains and losses, which is critical in prospect theory. Therefore, the existing literature cannot address the question of whether ego depletion enhances the automatic biases described by the value function of prospect theory—i.e., whether ego depletion enhances the reflection effect and increases loss aversion. We here specifically test this prediction.

Across three preregistered studies, we investigate the effect of ego depletion on risk taking in a series of standard, incentivized economic decision-making tasks that assess risk preferences in the gain domain, risk preferences in the loss domain, and loss aversion. Study 1 reports data collected by our lab as part of the Hagger *et al.* RRR³. Participants performed a computerized version of the letter ‘e’ task, followed by a set of four manipulation check questions, a multi-source interference task (MSIT; which was used as the outcome measure in Hagger *et al.*), a second set of manipulation check questions, and the risk tasks. Results from the letter ‘e’ task, the first set of manipulation checks, and the MSIT were reported in Hagger *et al.*³; the second set of manipulation checks and the risk-taking tasks were implemented by our lab only and therefore have not previously been reported. However, all parts of the study were included in our lab’s preregistered protocol.

To be sure of the results from Study 1, we conducted two additional studies in which we included a larger sample (Study 2: $n = 230$; Study 3: $n = 1,389$) and fine-tuned the risk-taking tasks to increase number of trials in the range where there seemed to be a tendency toward an effect in Study 1. In addition, we addressed some concerns that were raised regarding the Hagger *et al.* RRR. The main critique of the RRR was that the study failed to properly manipulate ego depletion. Specifically, the computerized version of the letter ‘e’ task omitted the habit-forming first phase, which may have reduced its effectiveness in reducing performance on the second task^{34,35}. Re-analyses of the Hagger *et al.* results suggest that ego depletion can be induced given appropriate depletion tasks³⁶. In Study 2, we induced ego depletion using a manipulation that has been recommended in recent literature^{16,17} and that had a significant effect in a recent multi-lab replication project³⁷—the Stroop task. In Study 3, we induced ego depletion using a version of the letter ‘e’ task that included the habit-forming first phase and that was based on materials from a recent multi-lab replication project which was conducted in response to the Hagger *et al.* RRR^{34,38}.

Results

Study 1. *Manipulation check.* Following the letter ‘e’ task, participants in the depletion condition reported significantly greater effort ($t_{95} = 3.63, p < 0.001$), difficulty ($t_{95} = 11.28, p < 0.0001$), and frustration ($t_{95} = 3.67, p < 0.001$), but not fatigue ($t_{95} = 1.26, p = 0.209$), than participants in the control condition (for means, see Table S2 in the Supplementary Information). However, after the MSIT, there was no difference in the level of effort, fatigue, or frustration between the two conditions (all $ps > 0.250$) and a difference in the opposite direction in difficulty ($t_{95} = -2.48, p = 0.015$).

Risk taking. Figure 1 displays the proportion of risky choices in each condition (depletion and control) in the gain domain, loss domain, and mixed gambles. Independent samples t-tests and Mann-Whitney U tests revealed no significant difference in the proportion of risky choices between the depletion and control condition, neither in the gain domain, nor in the loss domain, nor in the mixed gambles (see Table 1). Regression analyses controlling for age and gender found no significant effects either (see Table 2). In the gain domain, there was an unexpected effect of gender suggesting that women were more risk taking than men ($\beta = 0.10, SE = 0.05, p = 0.033$); however, there was no interaction between gender and condition (see Supplementary Table S3). Chi-square tests investigating each trial separately also revealed no significant difference in risk taking between ego depletion and control (see Fig. 2 and Supplementary Table S4).

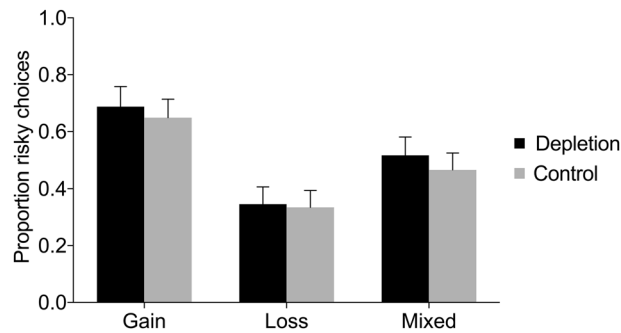


Figure 1. Proportion of risky choices in the gain domain, loss domain, and mixed gambles, as a function of condition (depletion vs. control) in Study 1. Error bars represent 95% CIs.

	Depletion		Control		Independent-samples t-test			Mann-Whitney U
	<i>M</i>	[95% CI]	<i>M</i>	[95% CI]	<i>t</i>	<i>p</i>	<i>d</i>	<i>p</i>
Gain	0.69	[0.62, 0.76]	0.65	[0.58, 0.71]	0.81	0.421	0.16	0.270
Loss	0.35	[0.29, 0.41]	0.33	[0.28, 0.39]	0.26	0.792	0.05	0.754
Mixed	0.52	[0.45, 0.58]	0.47	[0.41, 0.52]	1.18	0.240	0.24	0.291

Table 1. Significance tests of the difference in the proportion of risky choices in the depletion vs. control condition in the gain domain, loss domain, and mixed gambles in Study 1.

	Gain	Loss	Mixed
Depletion	0.042 (0.046)	0.014 (0.041)	0.049 (0.042)
Female	0.104* (0.048)	0.079 (0.049)	−0.059 (0.046)
Age	0.005 (0.010)	0.004 (0.009)	−0.000 (0.009)
Constant	0.495* (0.224)	0.225 (0.210)	0.493* (0.207)

Table 2. Regression analyses of risky choices in Study 1. *Notes.* This table reports OLS coefficient estimates (robust standard errors in parentheses). The dependent variable is the proportion of risky choices. “Depletion” is a dummy for the depletion condition. “Female” is a gender dummy. “Age” is the participant’s age in years. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Study 2. *Manipulation check.* Following the Stroop task, participants in the depletion condition reported significantly greater effort ($t_{228} = 4.24, p < 0.0001$), difficulty ($t_{228} = 7.45, p < 0.0001$), and fatigue ($t_{228} = 2.02, p = 0.045$), but not frustration ($t_{228} = -0.56, p = 0.579$), than participants in the control condition (for means, see Supplementary Table S5).

Risk taking. Figure 3 displays the proportion of risky choices in each condition (depletion vs. control) in the gain domain, loss domain, and mixed gambles. There was no significant difference in the proportion of risky choices between the depletion and control condition, neither in the gain domain, nor in the loss domain, nor in the mixed gambles (see Table 3). Regression analyses controlling for age and gender found no significant effects either (see Table 4); however, note that the regression analyses were performed on a smaller sample, since not all participants reported age and gender. In the mixed gambles, there was a significant effect of gender suggesting that women were less risk taking than men ($\beta = -0.09, SE = 0.03, p = 0.007$); however, there was no interaction between gender and condition (see Supplementary Table S6). Chi-square tests investigating each trial separately also revealed no significant difference in risk taking between depletion and control (see Fig. 4 and Supplementary Table S7).

Pooled data from studies 1 and 2. In an additional analysis that was not specified in the preregistration, the data from studies 1 and 2 were pooled in order to investigate an overall effect of ego depletion on risk taking. This analysis revealed no significant effect (see Supplementary Table S8).

Study 3. *Manipulation check.* Following the letter ‘e’ task, participants in the depletion condition reported significantly greater difficulty ($t_{1387} = 8.11, p < 0.001$), fatigue ($t_{1387} = 2.09, p = 0.037$), and frustration ($t_{1387} = 3.27, p = 0.001$), but not effort ($t_{1387} = 1.24, p = 0.215$), than participants in the control condition (for means, see Supplementary Table S9).

Risk taking. Figure 5 displays the proportion of risky choices in each condition (depletion vs. control) in the gain domain, loss domain, and mixed gambles. There was no significant difference in the proportion of risky choices

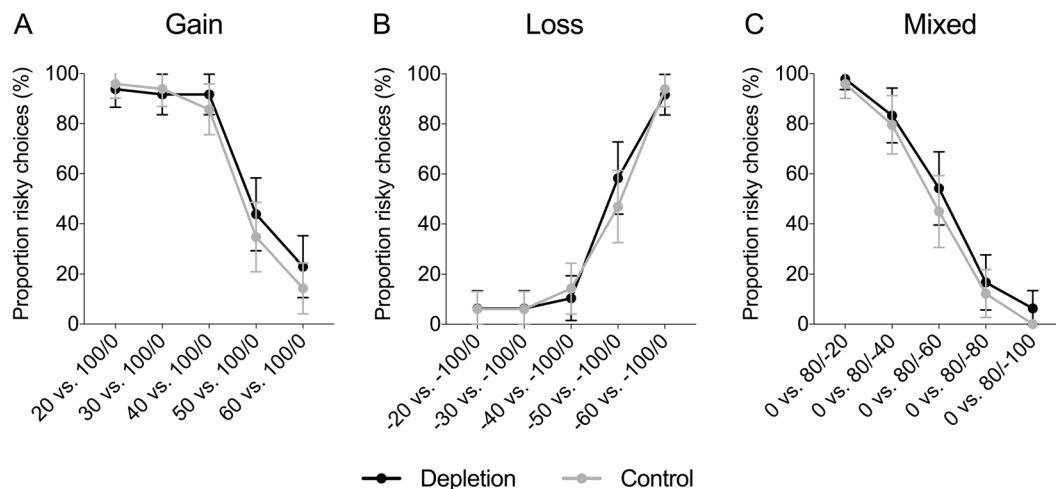


Figure 2. Proportion (%) of risky choices per trial in the (A) gain domain, (B) loss domain, and (C) mixed gambles, as a function of condition (depletion vs. control) in Study 1. Error bars represent 95% CIs.

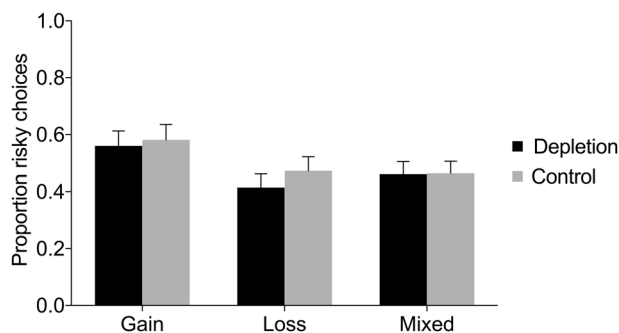


Figure 3. Proportion of risky choices in the gain domain, loss domain, and mixed gambles, as a function of condition (depletion vs. control) in Study 2. Error bars represent 95% CIs.

	Depletion		Control		Independent-samples t-test			Mann-Whitney U
	<i>M</i>	[95% CI]	<i>M</i>	[95% CI]	<i>t</i>	<i>p</i>	<i>d</i>	<i>p</i>
Gain	0.56	[0.51, 0.61]	0.58	[0.53, 0.64]	-0.55	0.581	0.07	0.511
Loss	0.41	[0.37, 0.46]	0.47	[0.42, 0.52]	-1.68	0.094	0.22	0.061
Mixed	0.46	[0.42, 0.51]	0.46	[0.42, 0.51]	-0.10	0.920	0.01	0.817

Table 3. Significance tests of the difference in the proportion of risky choices in the depletion vs. control condition in the gain domain, loss domain, and mixed gambles in Study 2.

	Gain	Loss	Mixed
Depletion	-0.010 (0.043)	-0.049 (0.039)	-0.003 (0.035)
Female	0.060 (0.043)	-0.029 (0.038)	-0.093** (0.034)
Age	0.000 (0.004)	0.002 (0.039)	-0.001 (0.003)
Constant	0.521*** (0.104)	0.441*** (0.097)	0.532*** (0.073)

Table 4. Regression analyses of risky choices in Study 2. *Notes.* This table reports OLS coefficient estimates (robust standard errors in parentheses). The dependent variable is the proportion of risky choices. “Depletion” is a dummy for the depletion condition. “Female” is a gender dummy. “Age” is the participant’s age in years. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

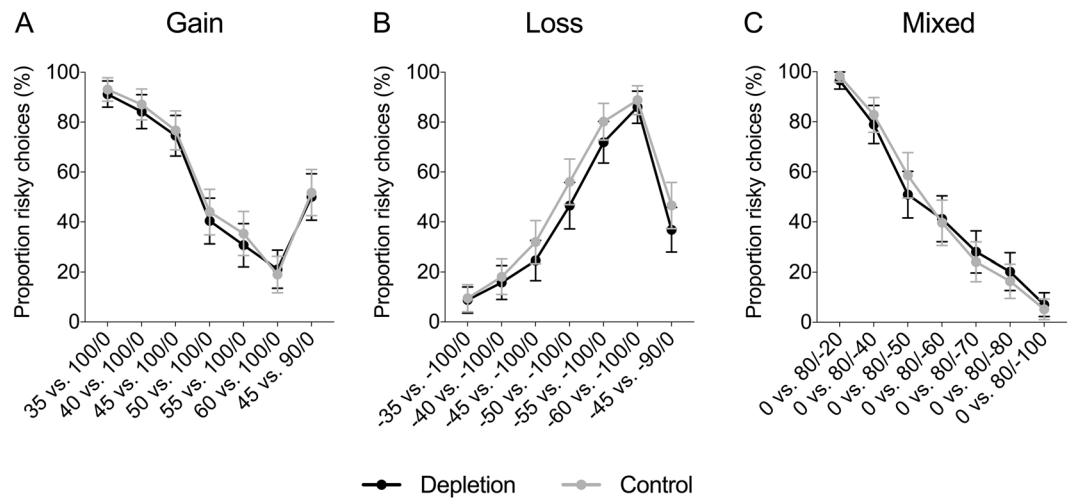


Figure 4. Proportion (%) of risky choices per trial in the (A) gain domain, (B) loss domain, and (C) mixed gambles, as a function of condition (depletion vs. control) in Study 2. Error bars represent 95% CIs.

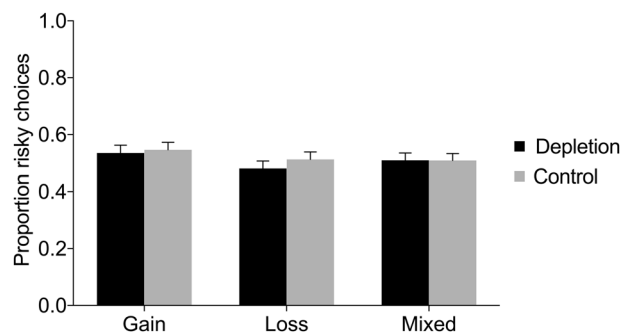


Figure 5. Proportion of risky choices in the gain domain, loss domain, and mixed gambles, as a function of condition (depletion vs. control) in Study 3. Error bars represent 95% CIs.

	Depletion		Control		Independent-samples t-test			Mann-Whitney U
	<i>M</i>	[95% CI]	<i>M</i>	[95% CI]	<i>t</i>	<i>p</i>	<i>d</i>	<i>p</i>
Gain	0.54	[0.34, 0.38]	0.55	[0.34, 0.38]	-0.59	0.558	0.03	0.587
Loss	0.48	[0.33, 0.37]	0.51	[0.34, 0.38]	-1.68	0.093	0.09	0.090
Mixed	0.51	[0.32, 0.35]	0.51	[0.32, 0.35]	0.05	0.960	0.003	0.948

Table 5. Significance tests of the difference in the proportion of risky choices in the depletion vs. control condition in the gain domain, loss domain, and mixed gambles in Study 3.

between the depletion and control condition, neither in the gain domain, nor in the loss domain, nor in the mixed gambles (see Table 5). Regression analyses controlling for age and gender found no significant effects either (see Table 6). In the gain domain, there was a significant effect of gender suggesting that women were less risk taking than men ($\beta = -0.04$, $SE = 0.02$, $p = 0.040$); however, there was no interaction between gender and condition (see Supplementary Table S10). Chi-square tests investigating each trial separately also revealed no significant difference in risk taking between depletion and control, except on one trial (see Fig. 6 and Supplementary Table S11).

Discussion

We investigated the effect of ego depletion on risk taking. Across three preregistered studies (total $n = 1,716$), we find no evidence that ego depletion results in more prospect-theory-like behavior. Specifically, participants who had performed a difficult version of the letter 'e' task (Studies 1 and 3) or the Stroop task (Study 2) were not significantly less risk taking in the gain domain, more risk taking in the loss domain, or more loss averse, compared to participants who had performed an easy version.

One possible explanation for our null findings is that the effect of ego depletion itself is either non-existent or too small to produce a consistent effect on risk taking, at least in the lab. This suggestion might seem counter-intuitive given that the manipulation checks indicated that participants in the depletion condition exerted more

	Gain	Loss	Mixed
Depletion	-0.016 (0.019)	-0.027 (0.019)	0.005 (0.018)
Female	-0.040* (0.020)	0.034 (0.019)	0.017 (0.018)
Age	-0.001 (0.001)	0.001 (0.001)	-0.001 (0.001)
Constant	0.609*** (0.035)	0.441*** (0.036)	0.532*** (0.033)

Table 6. Regression analyses of risky choices in Study 3. *Notes.* This table reports OLS coefficient estimates (robust standard errors in parentheses). The dependent variable is the proportion of risky choices. “Depletion” is a dummy for the depletion condition. “Female” is a gender dummy. “Age” is the participant’s age in years. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

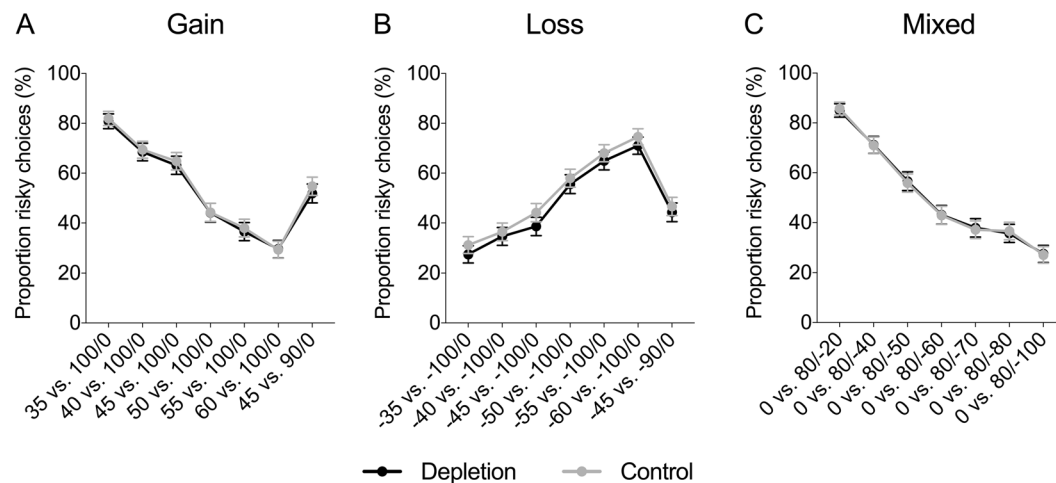


Figure 6. Proportion (%) of risky choices per trial in the (A) gain domain, (B) loss domain, and (C) mixed gambles, as a function of condition (depletion vs. control) in Study 3. Error bars represent 95% CIs.

effort (Study 1 and 2), reported that the task was more difficult (Study 1–3) and felt more frustrated (Study 1 and 3) and fatigued (Study 2 and 3) than control participants. However, self-reported depletion is not necessarily a measure of actual depletion of one’s self-control resources. Ego depletion is commonly linked to the strength model of self-control, which posits that exerting self-control in one task reduces performance on a second task that also requires self-control¹⁴. The theory has received extensive empirical support and an initial meta-analysis of 198 independent tests of ego depletion revealed a medium-to-large effect size¹⁵. However, results from recent multi-lab replications have been mixed. Some have found effects consistent with a null effect^{3,39}, others have found small but significant effects in the predicted direction^{37,38}. Part of the discussion has centered around the specific tasks that are used to induce and measure ego depletion, and efforts have been made to establish which tasks are most effective^{16,17}. However, despite using manipulations based on recent meta-analyses and recommendations, our studies failed to find a significant effect on risk taking. Given the current state of the ego depletion literature, we cannot rule out the possibility that the ego depletion effect itself is non-existent or very small or that it depends on factors not measured in the present studies.

An alternative explanation for our null findings is that participants were indeed depleted to some extent but that they were able to continue to exert self-control in the risk task because the possibility of a monetary reward motivated them to do so. Previous research suggests that increasing participants’ motivation to perform a task that requires self-control can improve their performance. For example, depleted participants who are paid well to drink a bad-tasting beverage (which arguably requires self-control) drink as much of it as non-depleted participants, but depleted participants who are paid poorly drink less of the bad-tasting beverage than non-depleted participants (as expected based on the ego-depletion literature)⁴⁰. Reminding participants of the importance of the task can also ameliorate ego depletion⁴¹. In light of these and similar findings, one might argue that the reason we found no effect is that the outcome measure, the risk task, was incentivized. However, studies on ego depletion and risk taking have used both incentivized and non-incentivized tasks and some have found effects in one direction, whereas others have found effects in the other direction—and yet others have found no effect at all^{18–30}. Therefore, it seems unlikely that the incentivized nature of the risk task is the sole reason for our null results.

A third possibility is that ego depletion has no effect on risk taking because decision making under risk is not dependent on self-control. This suggestion is arguably at odds with dual-process models of decision making, which place a central role of self-control in System 2 processing. Compared to the automatic, intuitive System 1, System 2 is controlled and effortful and relies on self-regulatory resources. When self-control is depleted, System 2 can no longer override System 1, which means that automatic biases such as the reflection effect of prospect theory are enhanced. Indeed, participants who make decisions under time pressure, compared to time delay, are more risk seeking for losses and less risk seeking for gains¹⁰ and rely more on affective (System 1) signals¹³. Similar results have been found for stress (which arguably also inhibits System 2)¹¹ and when comparing participants

who habitually rely more on System 1 and System 2 processing, respectively¹². The present research failed to find such effects and thereby failed to provide support for the prediction that ego depletion results in decisions that are more strongly in line with prospect theory. Although different manipulations of System 1–System 2 processing are assumed to have similar effects on behavior, it is possible that different manipulations seeking to inhibit System 2 have different behavioral effects. For example, acute pain (which arguably also inhibits System 2) has been shown to increase risk taking overall (especially for gains), which is somewhat at odds with the prediction that inhibition of System 2 processes results in more prospect-theory-like behavior⁴².

We suggest that future studies investigate self-control depletion that may arise after more prolonged exertion of effort (also known as mental fatigue⁴³) or after a long series of previous decisions (decision fatigue⁴⁴). For example, judges are less likely to grant parole to prisoners⁴⁵ and surgeons are less likely to decide to operate⁴⁶ toward the end of their work shift. Such approaches could inform both the self-control literature and theories of decision making.

Methods

Study 1. The preregistered protocol and data are available at the Open Science Framework (OSF)⁴⁷.

Participants. 102 participants were recruited from a subject pool at Linköping University for an experiment on “word and number recognition and reaction time”. They signed up using ORSEE⁴⁸. Three participants were excluded because they did not fulfil the language requirement; an additional two were excluded due to technical issues administering the risk-taking task. The final sample consisted of usable data from 97 participants (33% female; age 23.15 ± 2.55 years [$m \pm SD$]). All participants gave their written informed consent and were compensated with 100 SEK (approx. 12 USD) in addition to the payoff from one randomly selected decision. All methods were carried out in accordance with relevant ethical guidelines and regulations. According to guidelines from the Swedish research council concerning the Ethical Review of Research Involving Humans (SFS 2003:460), approval from an ethics committee is not required for behavioral research such as this study.

Materials and procedure. Participants were tested alone and were pseudo-randomly assigned to one of two conditions: depletion or control. They first completed the tasks described in Hagger *et al.*³, including the letter ‘e’ task (difficult or easy), four manipulation check questions measuring effort, difficulty, fatigue, and frustration, and the multi-source interference task (MSIT). They then answered the four manipulation check questions again and completed a series of three risk-taking tasks, administered in Qualtrics. In the risky gains task, they chose between receiving a sum of money with certainty and receiving a larger sum with 50% probability. In the risky losses task, they chose between losing a sum of money with certainty and losing a larger sum with 50% probability. In the mixed gambles, they chose to either accept or reject a gamble in which they had a 50/50 chance of receiving/losing a sum of money. Participants were informed that one of their decisions would be randomly selected for actual payment at the end of the experiment.

Data analysis. The main analysis of interest investigates the proportion of risky choices in the depletion vs. control condition in the gain domain, loss domain, and mixed gambles, using independent samples t-tests and Mann-Whitney U tests. To confirm the results, we perform regression analyses in which we control for age and gender. We finally investigate the proportion of participants who chose the risky option on each trial in the depletion vs. control condition, using chi-square tests. Following Hagger *et al.*³, we repeated the analyses while excluding participants ($n = 3$) who had less than 80% correct on the letter ‘e’ task; however, doing so did not change the results and we therefore do not report them in the paper.

Study 2. The hypotheses, independent and dependent variables, target sample size, and analysis plan were specified in the preregistration⁴⁹. Experimental scripts and data are available at OSF⁵⁰.

Participants. Participants were recruited using the same methods as Study 1. A power calculation in G*Power 3.1 indicated that 158 participants were needed to detect an effect size of $d = 0.4$ using an independent samples t-test with 70% power. One participant was excluded due to technical issues administering the Stroop task. The final sample consisted of usable data from 88 males and 88 females (age 24.75 ± 5.79 years [$m \pm SD$]), in addition to 54 participants who did not report age and gender, yielding a total sample of 230 participants. We recruited more participants than we specified in the preregistration, because we expected dropout and because the first 54 participants did not report age and gender due to an error in the script. All participants gave their written informed consent and were compensated with 100 SEK (approx. 12 USD) in addition to the payoff from one randomly selected decision. All methods were carried out in accordance with relevant ethical guidelines and regulations.

Materials and procedure. The experiment was conducted in a computer lab in sessions of up to 10 participants. Divider screens prevented participants from seeing each other’s responses. Participants were pseudo-randomly assigned to one of two conditions: ego depletion or control. Participants first completed a Stroop task, adapted from Dang *et al.*³⁷ and administered in E-Prime. On each of 256 trials, a color word was presented on the screen. Participants’ task was to indicate the font color of the word by pressing one of four buttons on the keyboard (e.g., “r” if the font color was red). In the depletion condition, 75% of trials were incongruent (i.e., the font color was different from the meaning of the word), while the remaining 25% were congruent (i.e., the font color matched the meaning of the word). In the control condition, all trials were congruent. Following the Stroop task, participants answered the same four manipulation check questions as in Study 1 and completed the risk-taking tasks

in Qualtrics. The risk tasks were the same as in Study 1, except we included more trials in the range where there seemed to be a tendency toward an effect in Study 1. Participants were informed that one of their decisions would be randomly selected for actual compensation at the end of the experiment.

Data analysis. Data analysis follows the same structure as Study 1. Excluding participants ($n = 7$) with less than 80% correct on the Stroop task did not change the results, so we report only the analyses that include the full sample.

Study 3. The hypotheses, independent and dependent variables, target sample size, and analysis plan were specified in the preregistration⁵¹. Experimental scripts and data are available at OSF⁵⁰.

Participants. Participants were recruited on Amazon Mechanical Turk (MTurk) for a study entitled “Cognitive Tasks”. A power calculation in G*Power 3.1 indicated that 788 participants were needed in order to detect a small effect size ($d = 0.2$) using a two-tailed independent samples t-test with 80% power. The preregistration specified that we aimed to recruit 1,000 participants in order to account for potential dropout due to technical issues or failure to complete the tasks; however, because the dropout rate initially seemed higher than expected, we increased the sample size to 1,500 in order to ensure sufficient power. Participants were excluded if they did not complete the risk-taking tasks or if they participated more than once (if this were the case, we kept only the first instance). The final sample consisted of usable data from 789 males and 581 females (age 39.77 ± 12.38 years [$m \pm SD$]), in addition to 17 participants who did not report age and gender, yielding a total sample of 1,389 participants. All participants provided informed consent and were compensated with 3 USD in addition to the payoff from one randomly selected decision. All methods were carried out in accordance with relevant ethical guidelines and regulations.

Materials and procedure. The experiment was administered in Inquisit 5 (web-based version). Participants were randomly assigned to one of two conditions: ego depletion or control. Participants first completed the letter ‘e’ task, adapted from the Vohs *et al.* replication project³⁸. In the first phase, participants were presented with a passage of text and were instructed to delete all instances of the letter ‘e’. Participants worked on this task until they were done or until 7 minutes had passed, whichever came first. In the second phase, participants were presented with a different passage of text. Participants in the control condition were again instructed to delete all instances of the letter ‘e’. Participants in the depletion condition were instructed to delete all instances of the letter ‘e’, except if an ‘e’ was followed by a vowel or if a vowel came two letters before the ‘e’ (not counting spaces). Participants worked on this task until they were done or until 8 minutes had passed, whichever came first. Following the letter ‘e’ task, participants answered the same four manipulation check questions as in Study 1 and 2. They then completed the same risk-taking tasks as in Study 2, except incentives ranged from -1 to 1 USD. Participants were informed that one of their decisions would be randomly selected for actual payment at the end of the experiment.

Data analysis. Data analysis follows the same structure as Study 1 and 2. The primary analysis includes all participants who completed the risk tasks, excluding only those who participated more than once (an intent-to-treat analysis; included $n = 1,389$). The secondary analysis additionally excludes participants who did not comply with the instructions in the letter ‘e’ task. Specifically, participants were excluded if they met one or more of the following criteria: (1) they deleted less than 60 (out of 337) e’s or deleted all text in the first phase of the letter ‘e’ task; (2) they deleted less than 60 e’s in the second phase of the letter ‘e’ task (control condition) or they deleted less than 50 e’s and/or deleted more than 11 e’s that were followed by a vowel and therefore should not have been deleted (depletion condition). For participants in the depletion condition who deleted 9–10 e’s followed by a vowel, we manually inspected their response. Excluding participants based on these criteria resulted in a sample size of $n = 815$. Because results remained the same across the primary and secondary analyses, we report only the primary analysis in the paper. Results from the secondary analysis are provided in the Supplemental Materials (see Supplementary Tables S12–S15 and Supplementary Figs S1 and S2).

Data Availability

Data are available at the Open Science Framework (OSF)⁵⁰.

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Author Contributions

All authors contributed to the study concept and design. L.K. collected the data. L.K. and D.A. analyzed the results. L.K. wrote the first draft of the paper and G.T. provided revisions. All authors approved the final version.

Additional Information

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