Title: The impact of self-control cues on subsequent monetary risk-taking

Running Head: Impact of self-control cues on gambling

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Author’s contribution. Damien Brevers, Jennifer Foucart, Ofir Turel, Anais Bertrand, Mikael Alaerts, Paul Verbanck, Charles Kornreich and Antoine Bechara designed the study and wrote the protocol. Damien Brevers conducted literature searches and provided summaries of previous research studies. Damien Brevers, Jennifer Foucart, Anais Bertrand, and Mikael Alaerts recruited the participants and collected the data. Damien Brevers, Ofir Turel, Anais Bertrand, and Mikael Alaerts conducted the statistical analysis. Damien Brevers wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

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ABSTRACT

Background and aims. The “process-model” of self-control proposes that the ego-depletion effect is better explained by a switch between interest in “have-to” labor and cognitive “want-to” leisure, rather than being mainly due to a decrease in cognitive resources, as advanced by the “strength-model” of self-control. However, it is currently difficult to disentangle the “process-model” from the “strength-model” of self-control. Here, we employed a stepwise approach, featuring three studies, for testing the process model of self-control.

Methods. In study 1, we created a list of 30 self-control events for characterizing “have-to” conducts in the daily-life. In study 2, mental visualization of effortful self-control events (“have to”) and monetary risk-taking (“want-to”) were employed for testing the strength-model of self-control. In study 3, to test the process-model of self-control, participants were simply required to read self-control (or neutral) sentences.

Results. Study 1 provided evidence regarding external validly for the list of self-control events. Study 2 showed that mental visualization of effortful self-control events increases subsequent monetary risk-taking. Study 3 highlighted that the brief apparition of a self-control related sentence was sufficient for increasing risk-taking. These patterns were evidenced in the trial with the less advantageous gain/loss ratio.

Discussion. Altogether, these findings support the process-model of self-control in showing that triggering the semantic content of a “have-to” conduct, without its actual execution, is sufficient for modulating subsequent “want-to” activity.
Conclusions. These findings could contribute to advancing knowledge on how the high-availability of ready-to-consume rewards in modern environments is redefining humans’ self-control ability.

Keywords: self-control, ego-depletion, strength-model, process-model, gambling
INTRODUCTION

Self-control refers to one’s capacity to favor his or her abstract and distal goals when they are threatened by competing concrete and proximal goals (Baumeister et al., 1998, 2007; Tangney et al., 2004; Fujita, 2011). This requires from the individual the effortful override of thoughts, emotions, or impulses associated with inappropriate behaviors that produce strong immediate rewards, so that he or she could engage in behaviors that are consistent with desirable long-term goals that are often less rewarding in the near future (Baumeister et al., 2007).

Baumeister’s influential strength-model advances that self-control restraint relies on a limited resource equated with a muscle (Baumeister et al., 1998, 2007). This model posits that engaging in self-control quickly consumes one’s limited resource or energy leaving him or her in a state of “ego-depletion”. Consequently, when individuals engage in an effortful activity at Time 1, ability to exert self-control temporarily diminishes, and consequently performance on a different task at Time 2 typically deteriorates (for a meta-analyses see Hagger et al., 2010). Crucially, in this depleted state, further self-control attempts are prone to fail, as demonstrated across situations. For example, self-control efforts at t1 result in a higher tendency for eating unhealthy food (e.g., Baumeister et al., 1998; Salmon et al., 2016), taking financial risks (Fischer et al., 2012; Macrae et al., 2014; Schmeichel et al., 2010) or at pursuing impulsive choices (Blain et al., 2016; Nolet et al., 2015).

Inzlicht and colleagues recently challenged the strength-model of self-control by questioning the fact that ego-depletion is exclusively induced by a short-term loss of mental energy (Inzlicht & Scheibchel, 2012; Inzlicht et al., 2014). This theoretical account
proposes instead a “process-model”, which advances the idea that self-control failure is less about resource depletion, but more about the switching of task priorities from a “have-to” (i.e., tasks that are carried out through a sense of duty or contractual obligation and are often difficult to execute) to a “want-to” goal (i.e., tasks that are psychologically and physically enjoyable and/or easy to perform; Hockey & Earle, 2006; Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014; Kiesel et al., 2010). As such, ego-depletion should reflect individuals’ effort at maintaining a balance between cognitive labor and cognitive leisure (Inzlicht et al., 2014; see also, Goldfrab & Henik, 2014; Kool & Botvinick, 2014). In this context, ego-depletion stems from the individual tendency to switch from mentally demanding tasks to more rewarding (or less effortful) activities. Accordingly, it has been shown that effortful cognitive control is intrinsically aversive (Botvinick, 2007; Kool et al., 2010; Kool & Botvinick, 2014) and less frequently used when low-effort cognitive strategies (Goldfrab & Henik, 2007, 2013) or alternative beneficial habits (Duckworth, 2016; Galla & Duckworth, 2015) can be used. Offsetting this pattern, increasing motivation or preparation to perform effortful mental activities decreases their averseness and counteracts the desire for cognitive leisure (Alberts et al., 2011; Converse & Deshon, 2009; Kiesel et al., 2010; Kool et al., 2010; Muraven & Slessareva, 2003; Moller et al., 2006).

However, these findings do not necessarily preclude the possibility that ego-depletion could also be due to a diminution of cognitive resources. Indeed, both decreases in self-control abilities after effortful self-control activity (i.e., the strength-model of ego-depletion) and in the motivation to engage in further effortful work (i.e., the process-model of ego-depletion) could contribute to the modulation of performance on
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subsequent tasks (e.g., Dang et al., 2014). Hence, current findings do not allow to
disentangle the “process-model” from the “strength-model” of self-control. Here, we
present the results of three studies that can serve as a basis for doing so. By so doing, this
study can serve as a springboard for future research aimed at refining and setting
boundaries for the abovementioned theories.

In study 1, we created a list of 30 self-control events that should characterize “have-
to” conducts in the daily-life of college students (i.e., behaviors that require effortful
control in order to reach valuable goals; see Galla & Duckworth, 2015; Imhoff et al.,
2014). The objective of study 1 was to demonstrate sufficient external validly of the list
of self-control events, before using these items in studies 2 and 3. Specifically, because
self-control has often been negatively associated with impulsivity (e.g., Johnson et al.,
2013; Miller et al., 2009; Tsukayama, et al., 2012, 2013), we expect the average scores of
frequency and difficulty of daily-life self-control events to be associated with the UPPS
(Urgency, Premeditation (lack of), Perseverance (lack of), Sensation Seeking) Impulsive
Behavior Scale and its four dimensions (Whiteside & Lynam, 2001).

We next used in Study 2 the self-control events from study 1 to test the strength-
model of self-control (i.e., study 2 was not designed to differentiate between the strength-
model and the process-model). Specifically, mental visualization of effortful self-control
events (“have to”) and monetary risk-taking (“want-to”) were employed for inducing
effortful activity at Time 1 and for assessing task performance at Time 2, respectively
(Carr & Steele, 2010; Fischer et al., 2012; Macrae et al., 2014; Schmeichel et al., 2010).
The mental visualization of effortful events was employed for inducing effortful activity
at Time 1 based on previous research that used comparable methods for simulating self-
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control (e.g., Macrae et al., 2014). Indeed, mental simulations (e.g., reflection on running) trigger the same sensorimotor processes that operate during the actual execution of the imagined activity (Moulton and Kosslyn, 2009). Hence, just as self-control can be used in real time to prevent an unwanted outcome (Wegner, 1994), it can be simulated offline through the mental imagery of the self-control events (Wilson, 2002). It follows that ego depletion effects could also arise from the imagination of effortful self-control events at Time 1 (Macrae et al., 2014). Monetary risk-taking (i.e., gambling), was used as an index of “want-to” activity, that is, an equivalent to doing something that is easier or more pleasurable activity. This selection was based on previous studies that used monetary risk-taking as a leisure conduct that could produce strong immediate rewards (Carr & Steele, 2010; Schmeichel et al., 2010), and that showed that participants spent more money after they undertook self-control related conducts. We hypothesized that as compared to mental simulations of neutral events, the imagination of effortful self-control (at Time 1) would increase monetary risk-taking (at Time 2).

Lastly, on basis of the findings from the two first studies, study 3 aimed at testing the process-model of self-control. Specifically, we employed the same procedure as in study 2, with one exception: participants were simply required to read self-control (or neutral) sentences. This procedure was used to examine whether triggering the semantic content of daily life self-control events could increase monetary risk-taking. We hypothesized that as compared to reading neutral events, the brief reading of sentences describing effortful self-control (at Time 1) would increase monetary risk-taking (at Time 2). Findings supporting this assumption would be in line with the process-model of self-control in showing that triggering the semantic content of a “have-to” conduct, without its
actual enactment, is sufficient for modulating subsequent “want-to” activity.

STUDY 1

METHOD

Participants
Sixty-seven undergraduate students (19 to 33 years of age; mean = 20.83, SD = 2.87; 54 males) were recruited from the Faculty of Motor Science of the Université Libre de Bruxelles (ULB).

Measures

Daily-life self-control behaviors
Based on Imhoff et al. (2014), a list of 30 common daily-life behaviors requiring self-control was created. It contained events in which individuals have to either resist a short-term temptation (e.g., “to study instead of going out with friends”) or undertake short-term effort in order to reach long-term goals (e.g., “to stretch thoroughly after a run”). See full list of sentences in Table 1. For each sentence, we assessed the frequency and difficulty of the behavior by asking: “How often do you undertake the following behavior?” on a scale from 1 (never) to 5 (very often), and “How difficult is it for you to undertake the following behavior?” on a scale from 1 (not at all) to 5 (a lot), respectively. Participants were asked not to provide difficulty ratings for behaviors that they have never undertaken (by circling “not applicable”; see also Table 1 for the percentage of “not applicable” answers for each item, across all participants).

---INSERT TABLE 1 AROUND HERE---
**Trait self-control**

Participants completed the 13-item of the French version of the Brief Self-Control Scale (BSCS; Brevers et al., 2017; Tangney et al., 2004). Items (e.g., “I am good at resisting temptation”) were endorsed on a 5-point scale, where 1 = *not at all like me* and 5 = *very much like me*. Cronbach’s alpha was .81. Consequently, an average scale score was calculated (with higher scores indicating better self-control).

**Impulsivity**

We assessed self-reported impulsivity with the French Version of the UPPS Impulsive Behavior Scale (Van der Linden et al., 2006). The UPPS captures four dimensions (sub-scales) of impulsivity using 45 items: “urgency”, defined as the tendency to experience strong reactions under the condition of intense negative affect; “lack of premeditation”, describing a tendency not to take into account the consequences of an act before engaging in that act; “lack of perseverance”, encapsulating inability to remain focused on a task that may be boring and/or difficult; and “sensation seeking”, capturing a tendency to prefer and pursue activities that are stimulating or exciting coupled with openness to trying new and unconventional experiences.

**Ethics**

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Each participant gave informed consent to the experimental procedure, which was approved by ULB Institutional Review Board.
RESULTS and DISCUSSION

The frequency (Cronbach's $\alpha = 0.76$) and difficulty ($\alpha = 0.86$) aspects of daily-life self-control behaviors were sufficiently consistent across the 30 events on the list. We therefore averaged scores across the 30 items to obtain mean scores of frequency and difficulty of typical self-control behaviors (see also Table 1 for means and standard deviations of frequency and difficulty ratings for each of the 30 items). Pearson correlation between these two scales was negative and significant, $r(67) = -0.42$, $p < 0.001$.

A moderate correlation coefficient ($r(67) = -0.36$, $p < 0.05$) was observed between lack of perseverance and the index of frequency of daily-life self-control, indicating that the higher the frequency of daily-life self-control behaviors was, the lower the lack of perseverance was. No significant correlations was observed between the index of frequency of daily-life self-control and trait self-control, $r(67) = .15$, ns, self-reported scores of urgency, $r(67) = -.31$, ns, lack of premeditation, $r(67) = -.15$, ns and sensation-seeking, $r(67) = .03$, ns. By contrasts, several moderate to large correlation coefficients were observed with the index of difficulty of daily-life self-control behaviors, indicating that the higher the difficulty of daily-life self-control behaviors was, the lower trait self-control was, $r(67) = -.41$, $p < 0.01$, and the higher self-reported scores of urgency, $r(67) = .44$, $p < 0.01$, lack of premeditation, $r(67) = .33$, $p < 0.05$, and lack of perseverance, $r(67) = .49$, $p < 0.01$ were. All $p$-values were adjusted for multiple comparisons with Bonferroni correction.

Taken together, these findings suggest that the index of difficulty of daily-life self-control behaviors has a higher level of face validity than the index of frequency, as it correlates with the BSCS and three UPPS subscales. Therefore, the index of difficulty
was used in studies 2 and 3 for selecting individualized self-control behaviors.

In addition, an exploratory correlation analysis revealed moderate to large correlation coefficients between trait self-control and impulsivity, indicating that the higher trait self-control was, the lower the self-reported scores of impulsivity (urgency: \( r(67) = -.42, p < 0.01 \); lack of premeditation: \( r(67) = -.42, p < 0.01 \); lack of perseverance: \( r(67) = -.42, p < 0.01 \); and sensation-seeking: \( r(67) = -.42, p < 0.01 \)) were. This pattern is consistent with both the theoretical approach of self-control and previous findings on the relationships between impulsivity and trait self-control (e.g., Johnson et al., 2013; Miller et al., 2009; Tsukayama, et al., 2012, 2013).

STUDY 2

METHOD

Participants

Eighty undergraduate students (different from those who participated in study 1) were recruited from the Faculty of Motor Science of the Université Libre de Bruxelles. Participants were randomly assigned to the neutral (\( n = 40 \)) or self-control (\( n = 40 \)) gambling task conditions (see Table 2 for participants' characteristics). This sample size was matched to the highest sample size used in previous studies examining the impact of ego-depletion on financial risk-taking (Schmeichel et al., 2010).
Measures

Selection of Cue Events

Self-control condition. Cue events for this condition were selected from the list of 30 self-control behaviors detailed in study 1. Specifically, five sentences were selected, based on the highest score of difficulty obtained from a preliminary session in order to individualize cue events presented to each participant.

Neutral condition. Cue events used in the neutral condition were sentences referring to daily-life objects that do not involve any direct action from the individual (e.g. “an office table that includes two chairs”; “a building that has five floors”). The neutral sentences were the same across all participants. The list of sentences is given in Table 3.

---INSERT TABLE 3 AROUND HERE---

The Gambling Task and Experimental Conditions

We used a Coin Flipping Task adapted from Carr & Steele, 2010. Participants were presented with five coin-toss trials featuring the following gain/loss ratios: 6(gain)/2(loss) [expected value, EV, = 2], 6/3 [EV = 1.5], 6/4 [EV = 1], 6/5 [EV = 0.5], or 6/6 [EV = 0]. Each trial was divided into three stages: cue event presentation, gamble presentation, and gamble decision. Importantly, the five trials were presented in the following EV centered succession order: 6/2 [EV = 2], 6/5 [EV = 0.5], 6/6 [EV = 0], 6/4 [EV = 1], and 6/3 [EV = 1.5]. This was done to prevent choices from being driven by the anticipation of trial order succession that might induce, for instance, strategic or sequential patterns of decision-making in some participants.

Cue event presentation. After having pressed the space bar of the keyboard, participants
first viewed a short sentence on the computer screen during 4 seconds (secs) and had to read it carefully. After the 4 secs, a black screen appeared and participants were instructed to close their eyes for 30 secs and to visualize themselves undertaking the behavior from their own viewpoint (i.e. “to see the event through your own eyes”). A “beep” sound (length = 1 sec) signaled then to open their eyes. Five sentences describing self-control events were presented to participants from the self-control group conditions. Five sentences describing simple motor actions were presented to participants in the neutral condition.

_Gamble presentation and decision._ Participants were offered a 50% chance of winning 6€ and a 50% chance of losing an amount of money that varied between 2 and 6€ [EV ranging from 2 to 0]. No gamble featured negative expected values. During this stage, participants had to choose to gamble or not, using “Yes” and “No” buttons on each side of the screen. The gambles were not played. Hence, no reward/loss feedback was given to the participants during the gambling task.

_Materials_

The Coin Flipping Task (see Figure 2A) was programmed and ran using E-Prime (v. 2.0.1; Psychology Software Tools, Inc., Pittsburgh, Pennsylvania, US). The task was presented on a 13 inch computer screen viewed from a distance of approximately 0.5 m. Participants responded to each trial by pressing one of two buttons on a keyboard, which paralleled buttons on the screen. The choices were to take or not to take the gamble.

_Dependent measures_

The proportion of “YES/NO” response for each trial was used in order to examine level of gambling acceptance at each gain/loss ratio.
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**Control measures**

*Gambling acceptance tendency/predisposition.* Participants had to rate on a five-point scale, where 1 = *never* and 5 = *always*, whether they would agree to gamble with their own money in a coin flipping game, with the following gain/loss ratios: 6(gain)/2(loss), 6/3, 6/4, 6/5, or 6/6. A scale score was calculated as the mean of all items; higher scores indicated higher subjective level of gambling acceptance predisposition.

*Motivation for money.* We asked participants to report the frequency with which they would pick a 0.20 € coin from the street on a five-point scale, where 1 = *never* and 5 = *always* (Sescousse et al., 2010).

*Trait self-control.* Participants completed the Brief Self-Control Scale (BSCS; Tangney et al., 2004).

*Impulsivity.* The French version of the UPPS Impulsive Behavior Scale (UPPS; Van der Linden et al., 206) was administered.

*Problem gambling and gambling frequency.* We used the 20-item South Oaks Gambling Screen (SOGS; Lesieur & Blume 1987) to evaluate participants’ gambling-related behavior and problems. The SOGS is a widely used screening instrument for problem gambling and has been shown to be valid and reliable in community and clinical samples (Lesieur & Blume 1987). A total SOGS score of 5 or higher was used to classify participants as probable pathological gamblers or not (scores between 1 and 4 on SOGS typically indicate some problems with gambling; Lesieur & Blume 1987).

**Procedure**

**Preliminary session**

Participants first provided informed consent and were assured of the anonymity of their
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answers. They then filled-out questions capturing demographic information, rated the 30 self-control behaviors on frequency and difficulty, and completed measures of gambling acceptance predisposition and motivation for money. This session was undertaken collectively, approximately one-week prior to the laboratory session. Participants received no information on the gambling task featured in the laboratory session.

**Laboratory session**

Participants were tested individually in a quiet room located at the research unit of the Psychophysiology of Movement at the Faculty of Motor Science of the Université Libre de Bruxelles. Participants first received informed consent and task instructions (specific to their group condition) for the Coin Flipping Task. All participants received similar task-instructions that featured one practice trial in order to familiarize them with the task. The term “SENTENCE” was displayed during the cue event presentation of the practice trial. In other words, we did not use either neutral or self-control sentences during the practice trial in order to give similar instructions to participants from the two groups. Importantly, participants were informed that the task included only 5 trials and that they had a fifty-fifty chance to win 6€ or to lose a specific amount that varied across trials. They were then told that a lottery followed the gambling task. During the lottery, participants had to randomly pick one ball (out of five) containing a trial number (i.e., from 1 to 5). The loss or reward corresponded to (i) the participant's decision (to gamble or not) during the gambling task on this specific trial and (ii) the amount featured in the specific trial. If the participant decided not to gamble during this trial, they received 6€. If participants decided to gamble on a trial, they had to first decide between “head” or “tail”, and then the experimenter flipped a coin. Depending on the result of this gamble,
the winning or losing amount featured on the trial was added to or withdrawn from the 6€ payoff. Hence, participants were remunerated between 0€ and 12€. This procedure was undertaken in order to ensure that participants’ responses were consistent with their true preferences.

After being informed of the lottery procedure, participants performed the gambling task, played the lottery game, and completed the UPPS and SOGS questionnaires. Participants were then remunerated and thanked for their participation. See Figure 1 for a depiction of the experimental procedure.

---INSERT FIGURE 1 AROUND HERE---
---INSERT FIGURE 2 AROUND HERE---

Data analyses
Multivariate Analysis of Variance (MANOVA) was used to examine between-groups (neutral vs self-control) difference effect on control measures with normal distributions (the UPPS subscales and the BSCS). Mann-Whitney U tests were used to examine between-groups difference in control measures with non-normal distributions (weekly budget, SOGS gambling frequency, SOGS problem gambling severity, SOGS gambling budget, motivation for money, and gambling acceptance predisposition). Independent sample t-tests were used for comparing the neutral and the self-control groups on mean scores of frequency and difficulty on the list of 30 self-control behaviors. McNemar tests were used to examine within-groups difference in the proportion of accepted or refused gambles according to the type of trial. Lastly, Chi-square tests were performed to examine the proportion of participants (between the neutral and the self-control group)
who accepted or refused the gamble, separately for the five trials of the gambling game. All $p$-values were adjusted for multiple comparisons with Bonferroni correction.

**Ethics**

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Each participant gave informed consent to the experimental procedure, which was approved by ULB Institutional Review Board.

**RESULTS AND DISCUSSION**

**Characteristics of study participants**

MANOVA revealed that participants from the self-control and the neutral groups did not differ on UPPS subscales and BSCS (Pillai’s Trace value = 0.08, $F(5, 73) = 0.63, p = .27$). Moreover, all pairwise comparisons (Fisher’s Least Significant Difference) revealed $p$-values > .12. Mann-Whitney U tests revealed that participants from the self-control and the neutral groups did not differ on weekly budget ($U = 706.50, Z = -0.54, p = .59$), SOGS gambling frequency ($U = 708.50, Z = -0.71, p = .48$), SOGS problem gambling severity ($U = 762.00, Z = -0.21, p = .83$), SOGS gambling budget ($U = 773.50, Z = -0.07, p = .95$), motivation for money ($U = 681.00, Z = -1.18, p = .24$), and gambling acceptance predisposition ($U = 720.50, Z = -0.77, p = .44$).

Regarding the list of 30 self-control behaviors, the self-control and neutral groups did not differ in self-control difficulty, $t(78) = 0.60, p = 0.74$ and self-control frequency, $t(80) = 0.74, p = 0.71$.

**Gambling acceptance** (see Table 2 for descriptive statistics)
McNemar tests revealed that the proportions of gambles differed between all gambling game trials (all $p < .01$), except for between the 6(gain)/5(loss) and the 6/6 trials ($p = 1.00$; see Figure 3A). Chi-square tests revealed that, as compared with the neutral group, a higher proportion of the self-control group accepted the gamble in trials featuring the 6/6 and 6/4 ratios, $X^2(1, N = 80) = 13.87, p < 0.001$, $X^2(1, N = 80) = 8.21, p = 0.02$, respectively (see Figure 3A). No between-groups differences were observed in the 6/2, 6/3 and 6/5 trials of the gambling game (all $p > .83$, see Figure 3A).

Taken together, results from study 2 are in line with the literature (e.g., Macrae et al., 2014) in showing that mental visualization of effortful self-control events (as compared to neutral situations) increases subsequent gambling acceptance.

---INSERT FIGURE 3 AROUND HERE---

STUDY 3

METHOD

Participants

A new sample of eighty undergraduate students was recruited from the Faculty of Motor Science of ULB. Participants were randomly assigned to the neutral ($n = 40$) or self-control ($n = 40$) gambling task conditions.

Measures

Selection of cue events

We used the same methods of cue events selection as in study 2.

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This task was similar to this employed in study 2, except for the cue event presentation stage. Specifically, participants viewed five sentences on the computer screen, each for 4 secs (see Figure 2B). They were instructed to read carefully (and quietly to themselves) each sentence. In the self-control group condition, sentences focused on self-control events, and in the neutral condition, sentences focused on simple motor actions.

Materials, dependent measures, and control measures

We used similar materials, dependent measures and control measures as in study 2.

Procedure

Preliminary session

We used a similar procedure to those used in study 2.

Laboratory session

This task was similar to this employed in study 2, except for task instructions: for each trial of the Coin Flipping Task, participants were instructed to read the sentence instead of to visualize themselves undertaking the behavior (as in study 2).

Data analyses

Multivariate Analysis of Variance (MANOVA) was used to examine between-groups (neutral vs self-control) difference effect on control measures with normal distributions (the UPPS subscales and the BSCS). Mann-Whitney U tests were used to examine between-groups difference on control measures with a non-normal distribution (weekly budget, SOGS gambling frequency, SOGS problem gambling severity, SOGS gambling budget, motivation for money, and gambling acceptance predisposition). McNemar tests were used to examine the between-groups difference in the proportion of accepted or refused gambles according to the type of trial. Lastly, Chi-square tests were performed to
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examine the proportion of participants who accepted or refused the gamble, separately for the five trials of the gambling game. All $p$-values were adjusted for multiple comparisons with Bonferroni correction.

Ethics

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Each participant gave informed consent to the experimental procedure, which was approved by ULB Institutional Review Board.

RESULTS and DISCUSSION

Characteristics of study participants (see Table 2 for descriptive statistics)

MANOVA revealed that participants from the self-control and neutral groups did not differ on UPPS subscales and BSCS (Pillai’s Trace value = 0.04, $F(5, 73) = 0.66, p = .43$). Moreover, all pairwise group comparisons (Fisher’s Least Significant Difference) revealed $p$-values > .17. Mann-Whitney U tests revealed that participants from the self-control and the neutral groups did not differ on weekly budget (U = 600.50, Z = -1.93, $p = .06$), SOGS gambling frequency (U = 784.00, Z = -0.16, $p = .88$), SOGS problem gambling severity (U statistic = 746.50, Z = -0.61, $p = .54$), SOGS gambling weekly budget (U = 786.50, Z = -0.14, $p = .89$), motivation for money (U = 735.50, Z = -0.64, $p = .52$), and gambling acceptance predisposition (U = 778.50, Z = -0.21, $p = .64$).

Regarding the list of 30 self-control behaviors, participants from the neutral group reported higher mean scores of self-control difficulty, as compared to participants from the self-control group ($t(80) = 2.47, p = 0.01$). No difference was observed in the mean
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score of self-control frequency, $t(80) = 0.62$, $p = 0.50$.

Gambling acceptance

McNemar tests revealed that the proportions of gambling choice differed between all trials of the gambling game (all $p < .001$), except between the 6(gain)/5(loss) and the 6/6 trials ($p = .07$). Hence, with exception of the trials with the two lowest EV, the higher the EV was, the higher the level of gambling acceptance was (see also Figure 3B). Chi-square tests revealed that, as compared with the neutral group, a higher proportion of participants in the self-control group accepted the gamble in the trial featuring the 6(gain)/6(loss) ratio, $X^2(1, N = 80) = 7.44$, $p = 0.03$ (see Figure 3B). No between-groups differences were observed in the 6/2, 6/3 6/4 and 6/5 trials of the gambling game, all $p > .83$ (see also Figure 3B).

In sum, results from study 3 highlighted that the brief apparition of a self-control related sentence was sufficient for increasing the level of gambling acceptance.

Noteworthy, participants from the neutral group reported higher mean scores of self-control difficulty. This might have lowered the impact of the experimental manipulation. Nevertheless, the present study design did not allow to examine this research question (i.e., only sentences with higher levels of self-reported difficulty were used in the gambling paradigm). Further studies are thus needed to replicate the present study protocol with groups of participants that do not differ on self-reported scores of difficulty to undertake daily-life self-control behaviors. Another complementary alternative would be to examine whether levels of difficulty of daily-life self-control modulate the impact of self-control cues on subsequent monetary risk-taking. For instance, one option would be to implement three experimental conditions: one featuring neutral sentences, one
featuring self-control sentences with a low level of self-reported difficulty, and one featuring self-control sentences with a high level of self-reported difficulty.

GENERAL DISCUSSION

The present paper describes the findings of three complementary studies which aimed at testing the process-model of self-control. Study 1 demonstrated sufficient external validity of a list of self-control events, which were then used in studies 2 and 3. Next, in line with the strength-model of self-control (Baumeister et al., 1998, 2007), study 2 highlighted that mental visualization of effortful self-control events increased monetary risk-taking. Finally, study 3 showed that simply reading sentences related to daily life self-control was sufficient for increasing monetary risk-taking. This last finding provides some support for the process-model of self-control (Inzlicht & Scheichel, 2012; Inzlicht et al., 2014) in showing that evoking the content of a “have-to” conduct (i.e., daily-life self-control routines), without its actual enactment, is sufficient for increasing the gravitation toward a “want-to” activity (i.e., gambling). Importantly, in studies 2 and 3 we observed that the proportion of gambling acceptance was significantly increased in the trial featuring the less advantageous gain/loss ratio (i.e., 6gain/6loss).

As a whole, the present findings could contribute in advancing knowledge on how the high availability of ready-to-consume rewards in modern environments is redefining humans’ ability of self-control. Specifically, tempting behaviors have never been so readily available, easy to engage in, and difficult to resist (e.g., Billieux et al., 2015). This also encompasses activities featuring monetary-risk taking, such as sports betting. Indeed,
with easy access from a computer, tablet or phone, it is possible to bet everywhere, at every moment, such as before or during a game in play, and while simultaneously using different platforms (e.g., Brevers et al., 2018; Hing et al., 2016; Marchica, 2017).

Because it is currently possible to get access to and repeat rewarding “want-to” conducts without engaging in complex cognitive or physical processes, merely thinking of effortful “have-to” conducts could increase gambling temptation and risk-taking in a large range of individuals.

Interestingly, in study 2, we observed higher levels of gambling acceptance for the trial featuring the 6/6 gain/loss ratios and also for the trial featuring the 6/4 ratios, but not for the trial featuring the 6/5 ratio. This result might be an artifact of the trial order presentation (e.g., Brevers et al., 2016; Kwak & Huettel, 2018). Specifically, in the present study, the five trials of the Coin-Flipping Task were presented in the following EV centered succession order (6/2, 6/5, 6/6, 6/4, and 6/3). This procedure was adopted to prevent choices from being driven by the anticipation of trial order succession that might induce, for instance, strategic or sequential patterns of decision-making in some participants. However, this specific trial order might have induced conservative choices in participants for the trial featuring the 6/5 gain/loss ratio. Indeed, this trial directly followed the one with the 6/2 gain/loss ratio, that is, the trial featuring the highest level of expected value. Additional studies are thus needed to replicate findings from studies 2 and 3 by examining whether trial order can impact the level of gambling acceptance.

One limitation of this study is that we used gambling (i.e., monetary risk-taking), as an index of “want-to” activity, that is, an equivalent to doing something that is easier or more pleasurable activity. This selection was based on previous studies that used
monetary risk-taking as a leisure conduct that could produce strong immediate rewards (Carr & Steele, 2010; Schmeichel et al., 2010), and that showed that participants spent more money after they undertook self-control related conducts. Nevertheless, for some participants in the present study, high-risk wagers might have been flagged as stressful, aversive and possibly a cognitive burden to undertake (as opposed to a more leisurely or less cognitive-demanding activity). While groups of participants did not differ in the controls (e.g., self-reported level of gambling acceptance tendency, motivation for money, gambling frequency), it is still desirable that future research replicates the present study with a sample of gamblers, that is, individuals for which gambling is closely related to a “want-to” leisure/approach motivation activity. Moreover, it has been highlighted that problem gamblers are characterized by low trait self-control (e.g., Bergen et al., 2012) and by disrupted sensitivity to monetary loss and rewards (e.g., Brevers & Billieux, 2018; Brevers & Noël, 2013; van Holst et al., 2010). Hence, recruiting a sample of gamblers, ranging from non-problem to high-problem gambling, should allow to examine whether levels of trait self-control sensitivity to loss and rewards could modulate the impact of self-control cues on monetary risk-taking.

Future research should also examine whether comparable increases of monetary risk-taking occur during simultaneous self-control. Indeed, in contrast to sequential self-control (which is used in the present study), it has been shown that exerting effortful self-control in one domain facilitates simultaneous self-control performance in unrelated domains (Tuk et al, 2015). This effect has been referred to as “inhibitory spillover” (Berman et al., 2009) or “transfer of cautiousness” (Verbruggen et al., 2012). Specifically, when people engage in a “have-to” task and inhibit a focal impulse, it
facilitates the inhibition of other impulses as well (e.g., proactive motor response inhibition diminishes monetary risk-taking while gambling; Verbruggen et al., 2012; Stevens et al., 2015). Therefore, it would be interesting to examine whether the onset of self-control related sentences impact differently monetary risk-taking when it is presented before (sequential order) or during (simultaneously to) gambling.

Additional studies are also needed in order to test whether the reading of self-control related sentences influence the level of monetary risk-taking during a gambling task featuring a higher number of repeated gambling choices, and with varying levels of gain-loss probability (e.g., the Cups Task; Weller et al., 2007). Indeed, in the present study the Coin-Flipping Task only included a single Yes/No response trial for each EV context. This might have lowered the statistical power of the observed effects and hampered direct comparisons of gambling acceptance across gain/loss ratios. Moreover, all trial featured a similar .50 gain-loss probability. Hence, the present results may not be generalizable to other gain-loss probability contexts.

Another limitation is that self-control sentences featured different types of “have-to” conducts. For instance, “to buy a fruit instead of a candy” involves health-related goals, whereas “to study instead of going out with friends” involves professional-related goals. Hence, future studies should examine whether the type of “have-to” conducts could impact differently the “want-to” conducts. Moreover, in contrast to the self-control sentences, the neutral sentences were not individualized. This might have lowered the impact of the experimental manipulation. In addition, the effects observed in the present studies could also be explained by other processes that are not related to either the process or strength models of self-control. For example, when individuals mentally
visualized daily-life self-control or read self-control sentences, it might have triggered a sense of over-confidence in the individual, so that they briefly believed that their choices (e.g. in the gambling paradigm) were more likely to be right, even in riskier circumstances. Further studies are needed to explore this assumption. Lastly, notwithstanding the effects revealed herein, it remains to be seen whether imagined self-control triggers effects on monetary risk-taking comparable to actual execution of self-control behavior. This issue merits further research.

In sum, we show that the viewing of sentences evoking daily-life effortful self-control, as compared to viewing neutral sentences, can increase subsequent monetary risk-taking. These findings provide initial support for the “process-model” of self-control, which posits that ego-depletion can be induced by a switch of interest between “have-to” and “want-to” conducts, rather than by a decrease of cognitive resources.
REFERENCES


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Impact of self-control cues on gambling


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### Table 1. Self-control cue events used in the experiments.

<table>
<thead>
<tr>
<th>Items</th>
<th>Frequency $M$</th>
<th>Frequency $SD$</th>
<th>Difficulty $M$</th>
<th>Difficulty $SD$</th>
<th>% NAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>To study instead of going out with friends</td>
<td>3.06</td>
<td>1.10</td>
<td>2.98</td>
<td>1.24</td>
<td>2.99</td>
</tr>
<tr>
<td>To buy a fruit instead of a candy</td>
<td>3.49</td>
<td>1.16</td>
<td>2.20</td>
<td>1.15</td>
<td>11.95</td>
</tr>
<tr>
<td>To study instead of going on the Internet</td>
<td>3.17</td>
<td>1.02</td>
<td>3.26</td>
<td>1.14</td>
<td>1.49</td>
</tr>
<tr>
<td>To study instead of watching a TV show</td>
<td>3.03</td>
<td>1.09</td>
<td>2.98</td>
<td>1.25</td>
<td>7.47</td>
</tr>
<tr>
<td>To go to bed early instead of going out with friends</td>
<td>3.15</td>
<td>1.21</td>
<td>2.56</td>
<td>1.22</td>
<td>4.48</td>
</tr>
<tr>
<td>To go running despite bad weather</td>
<td>2.48</td>
<td>1.42</td>
<td>2.80</td>
<td>1.51</td>
<td>26.87</td>
</tr>
<tr>
<td>To go to bed early instead of watching a TV show</td>
<td>2.81</td>
<td>1.57</td>
<td>2.62</td>
<td>1.44</td>
<td>10.45</td>
</tr>
<tr>
<td>To chose a healthy meal instead of a tasty but fatty meal</td>
<td>3.58</td>
<td>1.04</td>
<td>2.51</td>
<td>1.18</td>
<td>0.00</td>
</tr>
<tr>
<td>To buy water instead of a soda</td>
<td>3.91</td>
<td>1.20</td>
<td>1.78</td>
<td>1.05</td>
<td>4.48</td>
</tr>
<tr>
<td>To buy food for cooking instead of a ready-to-eat meal</td>
<td>4.00</td>
<td>1.30</td>
<td>1.81</td>
<td>1.09</td>
<td>5.98</td>
</tr>
<tr>
<td>To decide to turn down a cigarette offer</td>
<td>3.53</td>
<td>1.64</td>
<td>1.88</td>
<td>1.40</td>
<td>32.84</td>
</tr>
<tr>
<td>To decide not to drink alcohol at a party</td>
<td>2.37</td>
<td>1.27</td>
<td>2.76</td>
<td>1.42</td>
<td>28.36</td>
</tr>
<tr>
<td>To decide to turn down a dessert offer</td>
<td>2.90</td>
<td>1.37</td>
<td>2.24</td>
<td>1.25</td>
<td>31.46</td>
</tr>
<tr>
<td>To decide to postpone my cigarette break</td>
<td>1.93</td>
<td>1.45</td>
<td>1.63</td>
<td>1.12</td>
<td>67.16</td>
</tr>
<tr>
<td>To go to class instead of going out for a drink</td>
<td>3.36</td>
<td>1.48</td>
<td>2.04</td>
<td>1.14</td>
<td>10.44</td>
</tr>
<tr>
<td>To go-excercising instead of going out with friends</td>
<td>3.19</td>
<td>1.13</td>
<td>2.60</td>
<td>1.06</td>
<td>7.46</td>
</tr>
<tr>
<td>To do some cleaning instead of watching TV</td>
<td>3.09</td>
<td>1.22</td>
<td>2.35</td>
<td>1.11</td>
<td>7.46</td>
</tr>
<tr>
<td>To take notes in class instead of daydreaming</td>
<td>3.21</td>
<td>1.13</td>
<td>2.83</td>
<td>1.14</td>
<td>0.14</td>
</tr>
<tr>
<td>To decide to take out the clean dishes from the dishwasher</td>
<td>3.43</td>
<td>1.28</td>
<td>1.96</td>
<td>1.13</td>
<td>13.43</td>
</tr>
<tr>
<td>To decide to renew my public transport monthly pass</td>
<td>2.68</td>
<td>1.39</td>
<td>1.62</td>
<td>1.01</td>
<td>11.94</td>
</tr>
<tr>
<td>To resist eating a plate with meat</td>
<td>2.30</td>
<td>1.40</td>
<td>2.32</td>
<td>1.41</td>
<td>47.76</td>
</tr>
<tr>
<td>To classify documents instead of going on the Internet</td>
<td>2.92</td>
<td>1.22</td>
<td>2.44</td>
<td>1.21</td>
<td>0.06</td>
</tr>
<tr>
<td>To take out my pet instead of watching TV</td>
<td>1.96</td>
<td>1.46</td>
<td>1.31</td>
<td>0.74</td>
<td>88.08</td>
</tr>
<tr>
<td>To make my lunch instead of buying a sandwich</td>
<td>2.99</td>
<td>1.23</td>
<td>2.78</td>
<td>1.27</td>
<td>16.41</td>
</tr>
<tr>
<td>To wake up instead of pressing the “snooze” button</td>
<td>3.30</td>
<td>1.36</td>
<td>2.27</td>
<td>1.24</td>
<td>10.44</td>
</tr>
<tr>
<td>To pay attention in classes instead of talking with friends</td>
<td>3.11</td>
<td>1.46</td>
<td>3.31</td>
<td>1.62</td>
<td>17.91</td>
</tr>
<tr>
<td>To thoroughly stretch after a run</td>
<td>3.32</td>
<td>1.09</td>
<td>2.91</td>
<td>1.21</td>
<td>0.29</td>
</tr>
<tr>
<td>To take the stairs instead of the elevator</td>
<td>3.55</td>
<td>1.27</td>
<td>2.25</td>
<td>1.26</td>
<td>7.46</td>
</tr>
<tr>
<td>To wait until dinner before eating</td>
<td>3.56</td>
<td>1.27</td>
<td>2.00</td>
<td>1.02</td>
<td>7.46</td>
</tr>
<tr>
<td>To decide to read a book instead of going on the Internet</td>
<td>3.21</td>
<td>1.26</td>
<td>2.70</td>
<td>1.32</td>
<td>8.95</td>
</tr>
</tbody>
</table>

**Notes.** Frequency and difficulty scores are taken from study 1 only. All item scores ranged between 1 (minimum) and 5 (maximum). $M=$ Mean, $SD=$ Standard Deviation. % NAs = Percentage of “Not Applicable” answers for each item (across all participants from study 1, N = 67).
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Table 2. Sample characteristics for the neutral and the self-control conditions in studies 2 and 3.

<table>
<thead>
<tr>
<th></th>
<th>Neutral condition</th>
<th>Self-control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>n</em></td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Proportion of Male/female</td>
<td>17/23</td>
<td>18/22</td>
</tr>
<tr>
<td>Age</td>
<td>23.08 (5.96)</td>
<td>24.13 (5.09)</td>
</tr>
<tr>
<td>Weekly budget (in euros)</td>
<td>50.00 (35.00, 70.00)</td>
<td>60.00 (30.00, 90.00)</td>
</tr>
<tr>
<td>SOGS frequency</td>
<td>2.00 (2.00, 4.00)</td>
<td>2.00 (0.00, 5.00)</td>
</tr>
<tr>
<td>SOGS budget (in euros)</td>
<td>3.00 (3.00, 3.00)</td>
<td>3.00 (1.00, 4.00)</td>
</tr>
<tr>
<td>SOGS severity</td>
<td>0.00 (0.00, 1.00)</td>
<td>0.00 (0.00, 1.00)</td>
</tr>
<tr>
<td>Gambling acceptance</td>
<td>3.20 (2.65, 3.60)</td>
<td>3.10 (2.25, 3.55)</td>
</tr>
<tr>
<td>Motivation for money</td>
<td>3.00 (2.00, 5.00)</td>
<td>2.00 (2.00, 4.00)</td>
</tr>
<tr>
<td>SCL total score frequency</td>
<td>3.20 (0.48)</td>
<td>3.26 (0.80)</td>
</tr>
<tr>
<td>SCL total score difficulty</td>
<td>2.49 (0.54)</td>
<td>2.48 (0.66)</td>
</tr>
<tr>
<td>BSCS</td>
<td>2.50 (0.50)</td>
<td>2.56 (0.37)</td>
</tr>
<tr>
<td>UPPS urgency</td>
<td>26.71 (4.83)</td>
<td>27.60 (5.16)</td>
</tr>
<tr>
<td>UPPS lack of premeditation</td>
<td>20.12 (5.06)</td>
<td>20.48 (4.29)</td>
</tr>
<tr>
<td>UPPS lack of perseverance</td>
<td>17.77 (3.60)</td>
<td>19.08 (3.59)</td>
</tr>
<tr>
<td>UPPS sensation seeking</td>
<td>32.67 (6.39)</td>
<td>33.20 (6.61)</td>
</tr>
<tr>
<td><strong>Study 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>n</em></td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Age</td>
<td>21.53 (2.71)</td>
<td>23.30 (5.24)</td>
</tr>
<tr>
<td>Male/female</td>
<td>16/24</td>
<td>18/22</td>
</tr>
<tr>
<td>Weekly budget</td>
<td>37.50 (25.00, 67.50)</td>
<td>55.00 (36.25, 80.00)</td>
</tr>
<tr>
<td>SOGS frequency</td>
<td>2.00 (1.00, 4.00)</td>
<td>2.50 (1.00, 4.00)</td>
</tr>
<tr>
<td>SOGS budget</td>
<td>3.00 (1.00, 3.00)</td>
<td>3.00 (1.00, 3.00)</td>
</tr>
<tr>
<td>SOGS severity</td>
<td>0.00 (0.00, 1.00)</td>
<td>0.00 (0.00, 1.00)</td>
</tr>
<tr>
<td>Gambling acceptance</td>
<td>3.20 (2.65, 3.60)</td>
<td>3.30 (2.40, 3.75)</td>
</tr>
<tr>
<td>Motivation for money</td>
<td>3.00 (2.00, 4.00)</td>
<td>3.00 (2.00, 5.00)</td>
</tr>
<tr>
<td>SCL total score frequency</td>
<td>3.09 (0.46)</td>
<td>3.00 (0.53)</td>
</tr>
<tr>
<td>SCL total score difficulty</td>
<td>2.58 (0.48)</td>
<td>2.35 (0.37)**</td>
</tr>
<tr>
<td>BSCS</td>
<td>2.38 (0.38)</td>
<td>2.30 (0.48)</td>
</tr>
<tr>
<td>UPPS urgency</td>
<td>28.21 (5.02)</td>
<td>27.83 (6.47)</td>
</tr>
<tr>
<td>UPPS lack of premeditation</td>
<td>22.08 (4.65)</td>
<td>23.56 (4.78)</td>
</tr>
<tr>
<td>UPPS lack of perseverance</td>
<td>19.69 (4.38)</td>
<td>20.71 (3.91)</td>
</tr>
<tr>
<td>UPPS sensation seeking</td>
<td>33.36 (5.60)</td>
<td>35.00 (6.41)</td>
</tr>
</tbody>
</table>
Notes. SOGS = South Oaks Gambling Screen; SCL = self-control list; BSCS = Brief Self-Control Scale; UPPS = UPPS Impulsive Behavior Scale. Mean and standard deviation (in brackets) are reported for age, SCL scores, BSCS, and UPPS subscales. Median and 25th and 75th percentiles (in brackets) are reported for weekly budget, SOGS scores, gambling acceptance, and motivation for money. ** = p-value < 0.01; p-values were not corrected for multiple comparisons.

Table 3. List of sentences used in the experiments for the neutral condition (studies 2 and 3).

<table>
<thead>
<tr>
<th>A building that contains five levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>An office table that contains two chairs</td>
</tr>
<tr>
<td>An elevator that goes up to the second floor</td>
</tr>
<tr>
<td>A sheet of paper filled with text</td>
</tr>
<tr>
<td>A room painted in white</td>
</tr>
</tbody>
</table>
Figure 1. Experimental Procedure – Studies 2 and 3.
Figure 2. A. An illustration of a trial from the gambling task used in study 2; B. An illustration of a trial from the gambling task used in study 3.
Figure 3. A. In study 2, self-control group accepted significantly higher proportion of gamble the trials featuring 6/4 and 6/6 gain/loss ratios. B. In study 3, self-control group accepted significantly higher proportion of gamble the trials featuring 6/6 gain/loss ratios. p-values are being reported for Chi-square tests between the neutral and the self-control group, separately for the five trials of the gambling game. All p-values were adjusted for multiple comparisons with Bonferroni correction. * p < .05; *** p < .001