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Intense Self-Regulatory Effort Increases Need for Conservation and Reduces Attractiveness of Energy-Requiring Rewards

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Abstract: Exertion of self-control produces distinct motivational consequences: the motivation to conserve energy and the motivation to seek rewards. We propose that heightened conservation inhibits reward-seeking, but only when the pursuit of the reward entails substantial energy expenditure. In two studies, we manipulated self-regulatory effort and then had participants engage in an additional task that was either easy or difficult. In Study 1, we found that self-regulatory effort tended to heighten reward-sensitivity but only when the subsequent task was easy. In Study 2, we measured pupil dilation to assess reward sensitivity while participants viewed images of rewarding stimuli. When the need to conserve was intense, we observed reduced pupil dilation for rewards that were energy-requiring but not for those that were energy-giving.

Keywords: self-regulation, self-control, pupil size, conservation, reward-seeking

Successful self-regulation is important for a range of outcomes in life, from leading a healthy, well-balanced life, to achieving important life goals and maintaining satisfactory relationships with others (Tangney, Baumeister, & Boone, 2004). To achieve optimal self-regulation, individuals are required to exert self-control by resisting impulses and temptations, overriding habitual and dominant responses, and actively pursuing valued long-term goals – all of which are not easy tasks (Inzlicht, Schmeichel, & Macrae, 2014); a large body of research supports the notion that attempts at self-control are prone to failure (Baumeister, 2002; de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Moreover, research strongly suggests that impaired self-control opens the door to a host of potentially harmful and risky behaviors, ranging from substance abuse and aggression to high-risk gambling and compulsive shopping (Denson, DeWall, & Finkel, 2012; Faber & Vohs, 2004; Tangney et al., 2004). But while there is consensus on the observation that these behaviors do not typically serve the individual’s long-term best interest, they are less unequivocal on when, why, and how they come about. Based on the observation that self-control exertion is often effortful, researchers in the area of ego depletion tried to tackle this issue by hypothesizing and showing that exerting self-control at some point in time undermines subsequent self-control exertions (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister, Tice, & Vohs, 2018). The original model of depletion was challenged in several ways. On the one hand, recently, both meta-analytic evidence (Carter & McCullough, 2014) and replication studies (Hagger et al., 2016; Lurquin et al., 2016) indicate that the basic ego depletion effect size might be largely overestimated and therefore difficult to replicate. The debate on this issue is still open and large preregistered replication projects are ongoing. On the other hand, at a more theoretical level, the muscle metaphor, which describes self-control as a muscle that can be exhausted but also strengthened with training, and the idea that a physiological resource is actually drained by self-control exertion (Gailliot et al., 2007) are questioned by more recent models (e.g., Inzlicht & Schmeichel, 2012; Kotabe & Hofmann, 2015), emphasizing the role of motivation in understanding this phenomenon. Specifically, these models propose that self-control failure following previous self-control exertion is a consequence of an attentional and motivational shift rather than sheer exhaustion. That is, after previous self-control exertion, the individual...
experiences an increased motivation to act on impulse, and becomes attuned to signals promising immediate rewards. This may explain why, for example, in a state of low self-control, people fail to adhere to their long-term goal of eating healthy, and instead go for the tempting slice of pizza. Strikingly, our knowledge about the motivational mechanisms underlying self-control is yet far from complete. That is, is there a single or are there multiple motives at play affecting people’s pursuits following self-control exertion? And if the latter, how do these motives relate to each other? Are they unrelated and simply juxtaposed? Or are they interdependent? The present research seeks to answer these questions.

We start from the assumption that while the lure of temptations may indeed increase after exerting self-control, the observation that self-control exertion is effortful may point to a second motivational force that may be at work as well, and that may or may not be compatible with the first. That is, given the fact that self-control exertion is typically effortful, subsequent self-control may also suffer – not just because people shift their attention and motivation toward immediate rewards, but because people want to conserve their energy, recuperate, and/or restore lost energy (Muraven, Shmueli, & Burkley, 2006). If at least two motivational forces – reward seeking and energy conservation/restoration – drive behavior following self-control exertion, it may well be that the two are not simply juxtaposed, operating independently of each other. As we will articulate further, we advance the notion that the two motivational forces are actually interdependent and interact in regulating the individuals’ behavioral orientations in a way that they best serve more proximal or urgent self-regulatory need states.

In the present investigation, we propose and test the notion that following previous intense self-control exertion, the motivation to conserve energy will modulate the motivation to attain rewards, such that it will inhibit generic reward sensitivity in the face of subsequent effortful self-regulation. Hence, we propose that this inhibition will predominantly surface for rewards that require significant energy expenditure to attain and that do not uniquely serve the motive of recuperation. Under these conditions, interdependence manifests itself in the two motives operating hydraulically, such that an increase in conservation will drive a decrease in reward sensitivity. In contrast, when rewards do uniquely serve the recuperation motive, their sensitivity will be enhanced, rather than inhibited. The next section elaborates on these propositions.

Two Clusters of Behavioral Outcomes

The notion of two motivational drivers underlying the behavioral consequences of self-control exertion seems well supported in the literature. More specifically, the plethora of seemingly heterogeneous consequences of low self-control (see Muraven, 2012 for an overview) suggests that these consequences can be grouped into two broad clusters. On the one hand, some research demonstrates that self-control exertion fosters impulsive, uninhibited behavior aimed at pursuing indulgence and ad hoc self-gratification fueled by increased sensitivity to immediate rewards. For example, following effortful self-control exertion, people are prone to increase their alcohol intake (Muraven, Collins, & Neinhaus, 2002), respond more to sexual urges (Gailliot & Baumeister, 2007), engage in impulse spending (Vohs & Faber, 2007), and overeat (Kahan, Polivy, & Herman, 2003; Vohs & Heatherton, 2000). More generally, research by Schmeichel, Harmon-Jones, and Harmon-Jones (2010; for similar conclusion, see also Schmeichel, Crowell, & Harmon-Jones, 2015) has shown a direct impact of self-control exertion on immediate reward sensitivity. Indeed, in one of their studies (Study 3), exercising self-control was found to facilitate the perception of a reward-relevant symbol (i.e., a dollar sign) but not a reward-irrelevant symbol (i.e., a percent sign). Finally, using functional neuroimaging, Wagner, Altman, Boswell, Kelley, and Heatherton (2013) showed that compared with non-depleted dieters, depleted dieters showed greater food cue-related activity in the orbitofrontal cortex, a brain area associated with the reward value and desirability of palatable foods. These findings suggest that self-control exertion at least partly provokes subsequent self-control failure by shifting people’s motivation in the direction of immediately attainable rewards.

On the other hand, other research stresses the impact of self-control exertion on passivity, rest, and more generally, on the conservation or replenishment of lost energy. For example, Baumeister et al. (1998), in testing the ego depletion framework, found that compared to non-depleted individuals, depleted individuals were more passive and less inclined to engage in active behavior; for example, they waited longer before pushing a button to end a boring film. In addition, other studies have shown that self-control exertion results in reduced persistence on demanding tasks (e.g., Burkley, 2008; Fennis, Jansen, & Vohs, 2009; Schmeichel & Vohs, 2009). And more direct evidence comes from recent work by Jia and Hirt (2016), which showed that depleted participants’ task performance was a direct function of the implicit activation of a rest goal (Study 3). These findings are consistent with other studies suggesting that the tendency for passivity and behavioral inertia likely stems from the need to recuperate following self-control exertion, as replenishing lost energy is indeed served by inactivity, rest, and/or sleep (Friese, Hofmann, & Wiers, 2011; Tyler & Burns, 2009). Taken together, these findings point to a second motivator following self-control exertion: energy conservation or restoration. Evidently,
need for conservation and restoration can have other antecedents besides only self-control exertion. For example, it may well be triggered by other activities that are associated with the self, yet distinct from self-control exertion (e.g., following physical exercise or romantic involvement). It is also plausible that need for conservation could be rooted in stable individual differences with some individuals showing more intense proclivity to conserve and restore energies than others. Yet, among the various factors that may induce this motivation, we will focus our analysis on the need for conservation as originating from self-control exertion.

In sum, on the one hand, exerting self-control fosters approach-related, reward-seeking behaviors and on the other hand, it promotes conservation or restoration of energy resources for future needs. But we propose that these two motivational drivers do not operate in isolation. Indeed, it is likely that people must resolve the trade-off between immediate approach-related rewards on the one hand and energy conservation or recuperation on the other by establishing priorities or a hierarchy of needs. It is interesting to note that previous studies highlighting the reward-seeking behavioral outcomes of self-control exertion have typically presented participants with rewarding stimuli that did not require active efforts to pursue (low self-regulatory effort/high reward; e.g., participants were simply enabled to consume as much of an appetizing food as they wish, see Vohs & Heatherton, 2000), while studies stressing passivity and inertia typically used tasks that required active self-control to pursue, yet were generally non-rewarding (high self-regulatory effort/low reward; e.g., solving an impossible figure-tracing task, see Fennis et al., 2009).

Thus, what happens when these two motivational forces collide? In other words, what happens when self-control-exerted individuals are faced with a desirable reward that requires active efforts, and hence energy expenditure to acquire? Is the urge to seek rewards sufficiently intense to supersede the conservation motivation and the accompanying reluctance toward action? To our knowledge, only one study has directly examined this issue. Giacomantonio, Jordan, Fennis, and Panno (2014) pitted reward against effort in a study where they presented individuals who exerted (or did not exert) self-control with a reward-seeking task but varied the efforts required to attain the desirable rewards. Following previous self-control exertion or non-exertion, participants were presented with an adapted version of the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) where they could earn money by pumping a virtual balloon until it popped. The effort to obtain the reward was varied such that while half the participants performed the regular task using a clickable mouse, the other half had to engage in actual physical effort to obtain the reward (i.e., by using a hand pump to inflate the virtual balloon). Consistent with prior research, results showed that exercising self-control increased reward seeking, but only in the non-effortful condition. In contrast, in the more effortful physical-pumping condition, individuals quit sooner and hence showed less reward-seeking in the self-control exertion (vs. non-exertion) condition. But why did this happen? While this research suggests that under conditions of low self-control, conserving energy may dominate over pursuing immediate rewards, it does not answer the question of why that dominance occurs and whether it occurs under specific conditions or more generically.

Hence, the present study aims to extend these previous results by taking a more nuanced look at this question. That is, we aim to examine the relationship between both motives by assessing if, and when the two are related, and if so, how this interrelationship unfolds in the process of self-control exertion. Theoretically, there are two possibilities. First, the motivation to conserve energy following previous self-control exertion can merely “out-muscle” the motivation to gain rewards. If so, the two motivations would be unrelated but would “co-exist” – that is, both would be activated by the exertion of effortful self-control, and both may affect a particular outcome – but one is stronger. In a typical orthogonal design where both motives are manipulated and reward seeking is measured as an outcome, this account would require an additive, but not a multiplicative model, – the observation of either one or two main effects, but no interaction between the two. Study 1 of the current investigation used this design to address this issue.

A second, and arguably more likely possibility, would be that the motivation to conserve and the motivation to seek rewards are inter-related, such that when the motivation to conserve and restore energy is particularly intense, the motivation to seek rewards is actively inhibited and thus will decrease. This account would require a multiplicative (interactive), not an additive effect of both motives. Why should the two motivations be, at least to some extent, interdependent? Individuals often gain a reward only when investing considerable, sometimes excessive, effort, which entails several failed attempts and the expenditure of substantial personal resources (including energy). This effortful process to gain rewards is mismatched with the attempt to conserve and restore lost energy and this might solicit active inhibition of incompatible goals (Fishbach, Friedman, & Kruglanski, 2003; Shah, Friedman, & Kruglanski, 2002). On the other hand, extended self-regulatory effort might, under some conditions, prompt more reward seeking but may stifle it and boost energy conservation under others. This possibility is consistent with Kurzban, Duckworth, Kable, and Myers’ (2013) opportunity cost model (see also Botvinick & Braver, 2015). That is, active self-control is assumed to carry opportunity costs. The model suggests that people perceive the effort associated with active self-control exertion as the outcome of an (implicit) cost/benefit
computation between investing effort in the present self-regulation task or shifting to another task if the latter promises to yield higher benefits. Consistent with the tenets of this model, a perception of moderate opportunity costs may well shift motivation in the direction of increased reward sensitivity on another task while extreme opportunity costs will likely favor an acute recuperation or conservation motive that will actively suppress such reward seeking motivation. Or, paraphrasing van der Linden (2011) experiencing intense effortful self-control may serve as a stop-emotion prompting people to stop and recuperate even well before one's actual performance ability has suffered a serious decrease.

The reasoning that heightened levels of conservation might suppress sensitivity to rewards that are potentially conflicting with the main activated goal entails two important implications. First, in keeping with the reasoning above, modulation of the reward seeking motive by the conservation/restoration motive may be particularly pronounced when the level of initial energy expenditure is particularly high, that is, under conditions of intense self-regulatory effort. Second, the assumption of a potential incompatibility or goal conflict implies that different types of rewards may exist, some of which may be compatible and some of which may be incompatible with the goal of conservation/restoration. Thus, conservation versus reward seeking is not a zero-sum game. Instead, such conservation (and hence restoration) should not interfere, and may even promote, sensitivity to rewards that do not require great effort to be attained or enjoyed and/or that provide the potential of conservation (or restoration) of expended energy (e.g., delicious food or a relaxing day in a spa). However, such conservation and restoration goals should inhibit or reduce sensitivity to rewards that are particularly effortful to attain or consume and/or do not provide the potential restoration of lost energy (e.g., sex or an exciting day of canyoning). We examine this possibility in Study 2.

In sum, building on the distinction between rewards that are compatible (i.e., restorative) or incompatible (i.e., costly) with the goal of conservation, we propose that reward-seeking may be actively inhibited by conservation needs under conditions of intense, but not moderate self-regulatory effort. We also propose that this reward-seeking is not done in an indiscriminate way. That is, the motivation to conserve energy will modulate the motivation to attain rewards, such that it will inhibit reward sensitivity for generic rewards and/or rewards that do not uniquely serve the motive of recuperation, as well as rewards that require significant energy expenditure to attain. In contrast, in the context of intense self-regulatory effort, sensitivity to rewards that uniquely serve the recuperation motive will be enhanced (rather than inhibited). We will explore these propositions in the two studies outlined below using different types of rewards. Moreover, while Study 1 relies on self-report measures of reward seeking, Study 2 uses a direct psycho-physiological measure of reward sensitivity. In these studies, we report all measures, manipulations, and exclusions. We used convenience sampling for our studies, aiming at maximizing statistical power within the limits of practical feasibility in the labs where the data were collected (i.e., collecting as many observations as possible in the allotted lab time). Moreover, we decided only to analyze the data after data collection had stopped. Finally, we used G*Power sensitivity analyses to assess the power of our studies (see below for more details).

Moreover, although the terms self-control and self-regulation are frequently used interchangeably in the literature, we align with earlier conceptions in our work and conceive of self-control exertion as involving two main components: the repeated active suppression of prepotent responses - impulses, urges, or habitual and dominant responses on the one hand, and/or sustained higher order mental functioning on tasks that may not carry immediate rewards (e.g., long-term goals) on the other (see Fujita, 2011).

Study 1: Self-Regulatory Effort and the BAS

The purpose of Study 1 was to examine how self-regulatory effort, combined with an additional difficult or easy task, affects individuals’ generic sensitivity to rewards (as measured by the BAS scale; Carver & White, 1994). If the motivation to conserve and the motivation to consume are unrelated, with conservation merely being dominant in guiding behavior when self-control exertion is intense, we would expect to replicate previous research showing that, possibly, in addition to a conservation motive, effortful self-control promotes increased sensitivity to rewards (Schmeichel et al., 2010).

However, since we propose that conservation and reward-sensitivity motivations are not unrelated but rather interdependent when self-control is particularly effortful, we expected self-regulatory exertion followed by an additional difficult task to produce heightened conservation, which actively inhibits generic reward-seeking. In other words, we expect participants to be less sensitive to rewards when the need to conserve is intensified by an additional, difficult task.

Method

Participants and Design
Participants were 194 undergraduate students (40% female; $M_{age} = 21.18$, $SD = 2.48$) at a Dutch university. They
were randomly assigned to conditions in a 2 (self-control exertion: yes/no) × 2 (additional math task: easy/difficult) between-subject design. Participants were either paid €4 or given partial course credits for participation in the study. A sensitivity analysis using G*Power to detect the focal interaction (using a multiple regression fixed model assessing \( R^2 \) increase with three predictors) showed that the current sample yielded 80% power to detect an effect of \( f^2 = 0.04 \). Given that the typical published effect size in (social) psychology has an effect size of approximately \( f^2 = 0.04 \) (Richard, Bond, & Stokes-Zoota, 2003), adequate statistical power appears to be warranted in the current study.

**Procedure**

Participants were told that they were participating in a study examining people’s abilities to do both qualitative and quantitative tasks and, as a result, they would be doing both a story-telling and a math task. They were first asked to tell a story about themselves, in which we embedded the ease-of-task manipulation. Participants lastly completed the BAS/BIS scale (Carver & White, 1994) and some manipulation checks, as well as a series of demographic measures before being debriefed and dismissed.

**Manipulation of Self-Control Exertion**

Participants had to tell a story about themselves on any topic of their choosing. This story needed to last 3 min and was recorded by a voice recorder. In the self-control exertion condition, participants were prohibited from using the pronoun “I”, as well as any “pause words”, such as “eh”, “um”, and so forth. In keeping with our operational definition of self-control exertion, this task required the successive suppression of prepotent responses and so required extensive use of inhibitory control. In the no self-control exertion condition, participants were given no restrictions (see Schmeichel & Vohs, 2009).

**Additional Task**

Previous research found that engaging in a difficult cognitive task, including solving arithmetical operations, required attentional control and produced consequences similar to other manipulations of self-regulatory depletion (Converse & DeShon, 2009; Schmeichel, 2007; Tyler & Burns, 2009). Therefore, to increase people’s self-control exertion and the associated need for conservation, we subsequently asked participants to perform a difficult versus easy math task.

To manipulate difficulty of the mathematical task following the initial self-control exertion manipulation, we had participants complete 16 math expressions in their head; they were not allowed to use paper and pencil. These math expressions consisted of a variety of one- and two-digit numbers. However, in the difficult condition, these math expressions consisted of 10 positive and negative numbers (e.g., \( 18 + 13 + -12 + 10 + 17 + 16 + -5 + -17 + 3 + -7 \)), whereas, in the easy condition, these math problems consisted of two positive numbers (e.g., \( 4 + 7 \)).

To avoid confusion, from this point forward, we refer to the story-telling task as the *self-control task*, while we label the second task, the *math task*. Please note that these tasks align with our operational definition of self-control exertion with the story-telling task reflecting the prepotent response inhibition component and the math task reflecting the component related to resisting to impulses and temptations.

**Reward Sensitivity**

To measure our focal DV, we used the Behavioral Activation System (BAS)/Behavioral Inhibition System (BIS) Scale (Carver & White, 1994). While the scale has been developed to assess chronic individual differences, we align with previous self-regulatory research that has successfully used the scale in the role of a dependent variable (see Schmeichel et al., 2010). The full scale consists of 24 questions (\( \alpha = .72 \)). But for the purposes of our study aim and hypothesis, we only used the BAS reward responsiveness subscale.\(^1\) This subscale includes items about an individual’s positive responses to obtaining a reward (e.g., “I go out of my way to get things I want.”). Participants responded to all scale items using a 4-point response scale (1 = *very true for me*; 4 = *very false for me*). Positively worded items were reverse-scored so that higher scores corresponded to a greater agreement with the items for that subscale.

**Manipulation Checks**

We asked participants two questions to check for the success of our self-control exertion manipulation (i.e., “How much did you find the speaking task at the beginning of this study exhausting?; “How difficult did you find the speaking task that you did at the beginning of this study?”). Because the two items were highly correlated (\( r = .49 \)), we averaged the two items to form a self-control exertion manipulation check index. We also asked one question to measure how difficult people found the math task (i.e., “How difficult did you find the math problems that you did in this study?”). Participants responded to all items using a 7-point Likert scale (1 = *not at all*; 7 = *very much so*).

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\(^1\) There were no significant main effects or interactions between self-control exertion and task difficulty for the other three subscales (BIS, BAS-drive, or BAS-fun) that comprise this measure, thus we do not discuss them further.
Results

Manipulation Checks
As predicted, we found a main effect of self-control exertion on our manipulation check, $F(1, 190) = 26.22$, $p < .001$, $\eta^2_p = .12$, with those in the self-control exertion condition reporting that they found the task more difficult ($M = 3.54$, $SD = 1.49$) than those in the non-exertion condition ($M = 2.53$, $SD = 1.22$). There was no main effect of math task difficulty, $F(1, 190) = 0.12$, $p = .73$, $\eta^2_p = .00$ nor an interaction, $F(1, 190) = 0.94$, $p = .33$, $\eta^2_p = .01$ Similarly, there was a main effect of task difficulty for our math task difficulty manipulation check, $F(1, 190) = 85.62$, $p < .001$, $\eta^2_p = .31$, with those in the difficult condition reporting that the task was more difficult ($M = 2.78$, $SD = 1.41$) than those in the easy condition ($M = 1.23$, $SD = 0.90$). While there was no main effect of the self-regulatory task, $F(1, 190) = 0.16$, $p = .69$, $\eta^2_p = .00$, there was a significant, Self-Control Exertion $\times$ Difficulty interaction, $F(1, 190) = 4.60$, $p = .03$, $\eta^2_p = .02$, with those in the difficult condition tending to view the task more difficult if they first exerted self-control ($M = 3.00$, $SD = 1.57$) than if they did not ($M = 2.57$, $SD = 1.21$), $F(1, 190) = 3.24$, $p = .07$, $\eta^2_p = .02$, although the difference only approached conventional significance levels. No such difference existed for those in the easy condition, $F(1, 190) = 1.52$, $p = .22$, $\eta^2_p = .01$.

BAS Reward Sensitivity
To test our hypothesis that intense levels of self-control exertion may actively inhibit generic, non-restorative reward sensitivity, we specifically focused on the interactive effects of self-control exertion and difficulty of task on people’s BAS reward responsiveness subscale score. While there was no main effect of either self-control, $F(1, 190) = 0.09$, $p = .77$, $\eta^2_p = .00$ or difficulty of the math task, $F(1, 190) = 0.66$, $p = .42$, $\eta^2_p = .00$, on people’s BAS reward responsiveness, we did find the predicted self-control exertion $\times$ difficulty interaction, $F(1, 190) = 4.70$, $p = .031$, $\eta^2_p = .02$. We used simple main effect analyses to probe the interaction. First, while there was no impact on reward sensitivity of our self-control task for participants in the difficult math task condition, $F(1, 190) = 1.76$, $p = .19$, $\eta^2_p = .01$, we replicated earlier research (Giacomantonio et al., 2014; Schmeichel et al., 2010) showing that in the easy math task condition, participants showed increased reward sensitivity following the exertion of self-control ($M = 3.52$, $SD = 0.28$, 95% CI [3.44, 3.60]), compared to the no self-control exertion condition ($M = 3.40$, $SD = 0.35$, 95% CI [3.30, 3.50]), $F(1, 190) = 3.02$, $p = .08$, $\eta^2_p = .02$, although this increase fell short of conventional probability levels of statistical significance by a trivial margin. Moreover, in line with our predictions, simple main effects analyses indicated that there was no impact of type of math task on reward sensitivity for those in the non-effortful self-control conditions, $F(1, 190) = 0.92$, $p = .34$, $\eta^2_p = .01$. Participants that had exerted self-control and subsequently completed the difficult math task showed reduced reward sensitivity ($M = 3.37$, $SD = 0.37$, 95% CI [3.27, 3.44]) compared to those confronted with the easy math task ($M = 3.52$, $SD = 0.28$, 95% CI [3.44, 3.60]), $F(1, 190) = 4.34$, $p = .037$, $\eta^2_p = .02$ (Figure 1).

Discussion
In addition to demonstrating the success of our manipulations, these results show that confronting participants who previously engaged in effortful self-control with an additional task requiring effort dampened their sensitivity to generic rewards present in their environment. Although the effects should not be overstated in terms of size, the present findings are supportive of the view that conservation and reward seeking are not unrelated. That is, by showing that participants who exerted self-control only exhibited a heightened response to rewards when the conservation need was not raised by additional activities involving attentional control (i.e., difficult math task), we found support for our hypothesis that these two motives were interdependent.

One potential limitation of Study 1 resides in the fact that we did not directly assess participants’ motivation to conserve energy. That said, assessing participants’ motivation to conserve energy with a self-report measure would have been particularly difficult and prone to error given that people frequently lack insight into their inner states (Nisbett & Wilson, 1977). Another limitation is that we used the BAS scale as our measure of reward sensitivity. While we opted to use this measure as a DV to align with previous research (see Schmeichel et al., 2010), we acknowledge that the measure may have been suboptimal. First, the BAS is designed to measure a stable, individual difference trait.

Figure 1. BAS reward sensitivity as a function of self-control exertion and math task difficulty.
rather than a state-based preference, and as such may be less sensitive to detect state-induced effects, such as those that were focal in the present study. Moreover, while all items comprising the scale capture perceptions about experiencing rewards, some of these pertain to the anticipation, while others pertain to the attainment of rewards, with the latter dimension arguably being more relevant in the present context than the former. Yet, one may argue that these considerations essentially show that the present test of our hypotheses was a particularly conservative one and thus that the (subtle) effects found may indicate a phenomenon that may be more robust than the present findings suggest.

That said, this scale only measures what people project what they would do in their present state. To get a more accurate and predictive measure of people’s actual reward sensitivity and to more directly gauge the interplay between the two hypothesized motivations we use a psychophysiological measure in Study 2. In addition, while the BAS Scale items were not divided into the pursuit of rewards that required or did not require energy to attain, the majority of them implied some energy expenditure (e.g., “When I want something I usually go all-out to get it; I’m always willing to try something new if I think it will be fun.”). To test our hypotheses, the next study used a more sensitive measure that did not rely on self-report. Moreover, Study 2 was designed to test the idea that inhibition of rewards sensitivity only takes place for rewards that are incompatible with the goal of conserving or restoring energies (e.g., costly rewards). Conversely, under these conditions, reward sensitivity to restorative rewards should be strengthened.

Study 2: Self-Regulatory Effort, Difficulty, and Pupil Dilation

In Study 2, we aimed to investigate changes in reward sensitivity by examining pupil dilation during the presentation of images depicting different types of rewarding stimuli following effortful self-regulation. Consistent with the previous experiment, we hypothesized that when previous exertion (vs. no exertion) of self-control was followed by an additional difficult (vs. easy) task, individuals would be less responsive (i.e., show reduced pupil dilation) when facing rewarding stimuli – particularly rewarding stimuli requiring energy to attain. The underlying reasoning is that the conservation need solicited by the second (difficult) task interferes with the motivation to gain a reward, since pursuing a reward might be highly costly for the person.

Pupil dilation is a physiological measure that reflects increased sympathetic activity linked to emotional arousal (Bradley, Miccoli, Escrig, & Lang, 2008), detection of rewards (Bijleveld, Custers, & Aarts, 2009), and allocation of mental resources (Rondeel, Van Steenbergen, Holland, & van Knippenberg, 2015). As noted by Rondeel et al. (2015), stimuli that are perceived as important, significant or rewarding, are more likely to stimulate pupil dilation. Thus, we used pupil dilation as an indicator of the motivational relevance of the processed stimuli. The use of such a physiological measure offers critical advantages for the present research. From a methodological point of view, the variable provides a reliable indicator of a motivational process that is otherwise difficult to directly access. From a more theoretical angle, by measuring pupil dilation we can test the physiological reactions toward different types of rewarding stimuli and thus provide a stricter test of our theory. Indeed, we propose that there is a distinction between rewards that provide some type of gains for the organism in exchange for a significant energy loss (costly rewards) and rewards that are mainly connected with the conservation or restoration of the lost energy (restorative rewards). The first type of reward is the one that requires individuals’ initial energy expenditure to be attained. In this case, the individual trades off energy for a pleasurable experience (e.g., sex). For this reason, costly rewards might be, incompatible with the motive of energy conservation/restoration, mainly when this motive is particularly salient (i.e., under conditions of intense self-regulatory effort). This second type of reward provides more energy than that spent in the process of attaining it, thus preventing further expenditure of resources. It should also help the individuals to restore or compensate loss of resources (e.g., enjoying delicious food). Thereby, we assume that restorative rewards are compatible with the goal of energy conservation.

We propose that heightened conservation will reduce physiological activation in response to rewards that are potentially threatening to the main goal of conserving and restoring energy. Instead, heightened conservation motivation should increase physiological activation in response to compensatory rewards since they are serving the dominant motivational orientation. If, as we predict, the drop of reward sensitivity among an effortful self-regulatory task followed by a difficult task is due to augmented conservation motivation, we should find less physiological activation when viewing energy-requiring rewards (e.g., sex images), but more activation when viewing energy-giving rewards (e.g., food). Pertaining to energy-requiring rewards, the hypothesis is consistent with findings from Study 1, where more generic reward responsiveness was mitigated by increased need for conservation. Indeed, as we noted earlier, reward responsiveness measured by the BAS scale might mainly tap into energy-requiring, rather than energy-giving, rewards (e.g., exerting action to attain something: “I go out of my way to get things I want.”), which are incompatible with the goal of conservation.
In Study 2, we provided participants with several images of both costly and restorative rewards, as well as several neutral images. Specifically, costly rewards were images related to sex and restorative rewards were images related to food. We hypothesized that participants with high need for conservation would respond with less reward sensitivity to the costly reward (i.e., sex) images but more reward sensitivity to the restorative reward (i.e., food) images.

Within the sex-related images, we also distinguished between images depicting a single person or a couple in an explicitly erotic situation. While we assume that both types of erotic images are arousing, we anticipated that the rewarding potential, that is the perception that the image depicted an achievable reward, would be higher when one rather than two persons are represented, since the first image signals mate availability, while the latter does not. Thus, since erotic couple images would entail little or no rewarding potential, we expect that participants’ reaction to these images will be only weakly affected by our manipulations. We conducted a pilot study to test whether these assumptions were empirically supported. We will first describe the pilot study and subsequently describe the methodology and results of the main study.

Pilot Study

The pilot study was conducted on Amazon’s Mechanical Turk (Mturk) and involved 121 participants (47 women, $M_{age} = 34.28$, $SD = 8.97$) who rated a series of images selected from the International Affective Picture System (IAPS; Lang, 2005). Sample size was determined before any data were analyzed based on monetary budget. Sensitivity analysis using a repeated measures, within factor model with four groups (12 measurements), showed that the current sample yielded 80% power to detect an effect as small as $f^2 = 0.005$, equivalent to $\eta_p^2 = .005$, indicating a sufficiently powered pilot study. Images were selected from four categories: erotic single of the opposite sex (male or female depending on the respondent’s gender), erotic couple, delicious food, and neutral images (e.g., a screw, a lamp, a clock). We presented participants with three images from each target category and eight images from the neutral category. Each image was rated on three dimensions:

(a) potential reward (i.e., To what extent does what you see in this image offer you the potential for a personal reward?; To what extent do you wish you actually possessed what you see in this image?);
(b) arousal (i.e., To what extent do you find what you see in this image arousing?; To what extent do you find what you see in this image stimulating?);
(c) restoration of energy (i.e., To what extent does what you see in this image potentially provide you with a way to restore lost energy?; To what extent does what you see in this image potentially provide you with energy when you are feeling depleted or drained?).

Participants indicated their ratings on a 7-point response scale (1 = not at all; 7 = very much so).

For each dependent variable, we conducted a within-subject analysis of variance (ANOVA) comparing four levels: (1) erotic single; (2) erotic couple; (3) food; (4) neutral image.

As to potential rewards, the ANOVA showed a significant within-subject effect, $F(3, 118) = 113.74, p < .001, \eta_p^2 = .49$. Means, standard deviations, and results of post hoc analyses are reported in Table 1. As predicted, erotic couples were characterized by lower potential for reward than were erotic singles, $F(1, 120) = 4.28, p = .041, \eta_p^2 = .03$.

A within-subject ANOVA on arousal also revealed a significant overall effect, $F(3, 118) = 237.47, p < .001, \eta_p^2 = .66$. As can be noted in Table 1, perception of arousal did not differ between images of erotic singles and erotic couples ($F < 1$).

The same ANOVA was conducted on restoration and yielded significant results, $F(3, 118) = 114.59, p < .001, \eta_p^2 = .49$. Post hoc analyses reported in Table 1 showed that images of food were perceived as more restorative than both erotic singles, $F(1, 120) = 3.49, p = .06, \eta_p^2 = .03$, and erotic couples, $F(1, 120) = 5.59, p = .020, \eta_p^2 = .05$, with the difference for erotic singles falling short of conventional probability levels of statistical significance by a trivial margin. Ratings of erotic images (singles vs. couples) were not statistically different ($F < 1$).

Overall, the pilot study demonstrated that, although similar in terms of arousal, erotic singles were perceived as more potentially rewarding than erotic couples. In addition, food was perceived as more restorative than both types of

Table 1. Potential reward, arousal and restoration as a function of the type of image presented (pilot study)

<table>
<thead>
<tr>
<th></th>
<th>Potential reward</th>
<th>Arousal</th>
<th>Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>95% CI</td>
</tr>
<tr>
<td>Erotic single</td>
<td>4.25*a</td>
<td>2.00</td>
<td>3.89, 4.62</td>
</tr>
<tr>
<td>Erotic couple</td>
<td>3.97*b</td>
<td>1.78</td>
<td>3.65, 4.29</td>
</tr>
<tr>
<td>Food</td>
<td>4.07*a,b</td>
<td>1.51</td>
<td>3.80, 4.34</td>
</tr>
<tr>
<td>Neutral</td>
<td>1.56*c</td>
<td>0.87</td>
<td>1.41, 1.72</td>
</tr>
</tbody>
</table>

Note. Means sharing the same superscript are not significantly different from each other at $p < .05$. 

erotic images. And on all three dimensions considered, neutral images received lower ratings compared to all other categories.

Main Study

Method

Participants and Design

Participants were 109 undergraduate students (59% female, $M_{\text{age}} = 21.98, SD = 3.66$) from an Italian university. Participants were given partial course credit for participation in the study. The present study used a mixed design with self-control exertion (yes vs. no) and type of task (easy vs. difficult) as between-subject factors and type of image (erotic single, erotic couple, food, neutral) as the within-subject factor. As in Study 1, a $G^*\text{Power}$ sensitivity analysis to detect the focal interaction (using a multiple regression fixed model with three predictors) showed that the current sample yielded 80% power to detect an effect of $f^2 = 0.08$, again suggesting ample power.

Procedure

Participants were seated in the laboratory and provided with an explanation that the experiment consisted of several unrelated tasks. First, they completed a brief set of individual difference measures that were included for explorative purposes and not analyzed in the present work (i.e., Mindfulness Attention Awareness Scale, Brown & Ryan, 2003; Depletion Sensitivity, Salmon, Adriaanse, De Vet, Fennis, & De Ridder, 2014). They were asked to complete an $e$-crossing task designed to manipulate self-control exertion (see Hagger et al., 2016) followed by the same math task used in Study 1.

Note that between Study 1 and Study 2, the task used to vary the extent of sustained mental functioning (the math task) remained constant, whereas for the inhibitory control component we used different, yet both established paradigms in self-control (ego depletion) research (the story telling and e-crossing tasks, respectively). Using alternative self-control tasks would allow us to generalize over type of task, which would contribute to the robustness of our findings.

Subsequently, participants watched a series of images on an eye-tracker screen and, afterwards, completed manipulation checks and demographic measures, a measure of mood and were debriefed and thanked.

Manipulation of Self-Control Exertion

To manipulate self-control exertion, we adopted the $e$-crossing task developed by Baumeister et al. (1998). The task consisted of two phases. In the first phase, participants were instructed to circle all letters $e$ in a text. In the second phase participants were presented with a new text and, in the no self-control exertion condition, continued circling all letters $e$ with no restriction. In the self-control exertion condition, however, they had to adopt a new complex rule to select the $e$’s to be circled. More specifically, they were asked to circle only the $e$’s that were followed by another vowel or that were one additional letter away from another vowel. These new rules were complex to follow and, at the same time, required inhibition of the rule adopted in the first phase.

Additional Task

Following the logic of the previous study, the same task and difficulty manipulation used in Study 1 were adopted in the present study.

Eye-Tracking Apparatus and Stimuli

Right pupil diameter was recorded using the SMI-RED system (SensoMotoric Instruments GmbH, Germany), which permits remote, contact-free sampling pupil measurement at 120 Hz. A 9-point calibration was performed at the beginning of each session.

Initially, for practice purposes, participants viewed three neutral images that were not analyzed. Subsequently, participants viewed the same images pre-tested in the pilot study presented in random order. We increased the number of neutral images to 21 items. All images were converted into a grayscale. Following previous work (see Bradley et al., 2008), each picture was on the screen for 6 s. Before each picture, a grayscale image with a black fixation cross was presented for 10 s as an inter-trial interval. Baseline pupil diameter was measured during the last second of the inter-trial interval. Since the baseline stimulus was kept constant for the entire experiment, we created an average score of pupil diameter for all baselines.

Because pupil diameter is heavily affected by an initial light reflex that takes place during first 2 s of a stimulus onset (Bradley et al., 2008), we computed pupil dilation by subtracting the average pupil diameter of the baseline to the average pupil diameter measured during the last 4 s of the picture presentation. We were thus able to exclude variations due to light reflex from our analyses (for more details, see Bradley et al., 2008). A pupil dilation overall score, expressed in millimeters, per each of the four types of image was computed by averaging the pupil dilation of each image, with smaller negative scores indicating higher pupil dilation.

2 During the experimental session participants also viewed other images which, in most cases, were not selected from the IAPS database and were not tested on the dimensions examined in the pilot study. These images were included for explorative purposes and examples are: printed or internet commercials, landscapes, non-erotic images of males and females.
Manipulation Checks
To test the adequacy of the self-control manipulation, we asked our participants to rate the extent to which the e-crossing task was: *tiring, hard, difficult, demanding, complicated*. Participants responded using a 7-point scale (1 = not at all; 7 = very much so) and ratings were averaged into an overall index or perceived difficulty (\(\alpha = .75\)).

The same items were also used to check adequacy of the task difficulty manipulation (\(\alpha = .96\)).

Results
Manipulation Checks
A 2 (self-control exertion: yes/no) \(\times\) 2 (additional math task: easy/difficult) ANOVA was conducted on perceived difficulty of the self-control task. The analysis only yielded a significant main effect of self-control exertion, \(F(1, 105) = 9.09, p = .003, \eta^2 = .08\). As expected, the task was rated as more difficult when exertion of self-control was required (\(M = 3.84, SD = 0.91\)) than when not required (\(M = 3.26, SD = 1.05\)).

The same analysis was conducted on the perceived difficulty of the math task. As expected, the only significant finding was the main effect of the task difficulty manipulation, \(F(1, 105) = 154.28, p < .001, \eta^2 = .60\). More specifically, ratings of perceived difficulty were higher when participants were requested to solve difficult (\(M = 3.55, SD = 1.38\)) rather than easy (\(M = 1.19, SD = 0.29\)) math calculations.

Pupil Dilation
To test the main hypothesis of the present study, we conducted a 2 (self-control exertion: yes/no) \(\times\) 2 (additional math task: easy/difficult) \(\times\) 4 (erotic single vs. erotic couple vs. food vs. neutral images) mixed ANOVA with the last factor as a within-subject variable. As expected, a significant main effect of the type of image emerged, \(F(3, 103) = 203.94, p < .001, \eta^2 = .86\). Inspection of the means showed that, in terms of increased pupil dilation, image types were ordered as follows: erotic couple (\(M = -0.28, SD = 0.30, 95\% CI [-.33, -.22]\)), erotic single (\(M = -0.43, SD = 0.27, 95\% CI [-.48, -.38]\)), delicious food (\(M = -0.55, SD = 0.33, 95\% CI [-.61, -.49]\), and neutral images (\(M = -0.84, SD = 0.28, 95\% CI [-.89, -.78]\)). All contrasts were significant (all \(p's < .005\)).

The analyses showed a two-way interaction between self-control exertion and type of image approaching conventional levels of significance, \(F(3, 103) = 2.52, p = .06, \eta^2 = .07\), which was qualified by the predicted three-way interaction, \(F(3, 103) = 3.87, p = .01, \eta^2 = .10\). All means are reported in Figure 2A (easy math task condition) and Figure 2B (difficult math task condition). As can be noted in Figure 2A, when the self-regulatory task was followed by the easy math task, pupil dilation did not vary for any of the four types of images presented: erotic single, \(F(1, 105) = 0.89, p = .37, \eta^2 = .00\); erotic couple, \(F(1, 105) = 0.38, p = .54, \eta^2 = .00\); food, \(F(1, 105) = 0.08, p = .93, \eta^2 = .00\); neutral, \(F(1, 105) = 0.47, p = .50, \eta^2 = .00\).

However, a different pattern emerged when the difficult math task followed the self-control exertion task (see Figure 2B). More specifically, consistent with the notion that sex may be considered a costly reward, when viewing erotic single images, pupil dilation of participants who exerted self-control (\(M = -0.55, SD = 0.24, 95\% CI [-.65, -.45]\)) decreased as compared to participants who were not required to exert self-control (\(M = -0.34, SD = 0.26, 95\% CI [-.44, -.24]\)).\(F(1, 105) = 8.50, p = .004, \eta^2 = .08\).

In contrast, despite their lower overall dilation rate, when watching food-related images, pupils dilated more after self-control exertion (\(M = -0.48, SD = 0.31, 95\% CI [-.58, -.38]\)) than when they did not (\(M = -0.23, SD = 0.29, 95\% CI [-.34, -.12]\)).
rather than no self-control exertion \( M = -0.64, SD = 0.40, 95\% CI [-0.79, -0.48])\), \( F(1, 105) = 3.05, p = .083, \eta^2 = .03\) (albeit at a rate short of conventional probability levels of statistical significance), indicating such food-related images indeed function as restorative rewards. No differences emerged on the erotic couple images, \( F(1, 105) = .53, p = .47\), or neutral images, \( F(1, 105) = .124, p = .73\).

**Discussion**

The results of Study 2 supported our assertion that people’s preferences for costly (sex) versus restorative (food) rewards would only occur when effortful exertion of self-control was followed by a difficult task. When self-control was followed by an easy task, no such difference was found. We also found these (subtle) effects using objective physiological results – rather than via self-report measures, suggesting that there is a physiological component to these preferences.

**General Discussion**

The current results provide greater understanding of the complex dynamics behind self-control exertion by illustrating how the phenomenon impacts individuals’ reward sensitivity, as well as the conditions under which reward sensitivity is impacted. Specifically, in Study 1, we demonstrate that the two main motivational consequences of self-control exertion are interdependent rather than unrelated. The motive to conserve or restore lost energy due to intense self-regulatory effort not only leads to a tendency for passivity and inactivity, but also directly (albeit modestly) affects generic sensitivity to reward. Thus, while reward sensitivity tends to be heightened after self-regulatory effort, it drops when further attentional control is required by the task. This constitutes an advancement over previous work (Giacomantonio et al., 2014), in which the debate over conservation and reward-seeking being independent or interdependent motivations was unresolved.

From the results of the current investigation, we conclude that conservation and reward-seeking are often conflicting goals, with the dominant goal of conservation actively inhibiting the goal of reward seeking. From an evolutionary point of view, the dominance of conservation over reward seeking might also have been adaptive for survival; in our ancient hunter-gatherer past, it might have been beneficial for humans to disengage from pursuing unattainable, high-energy-consuming rewards. Imagine, for example, an exhausted caveman hunting. Indiscriminate sensitivity to reward might have motivated the primitive man to continue hunting a difficult, yet attractive prey with potential deleterious consequences, such as irrecoverable exhaustion, reduced abilities to hunt, and inability to defend against environmental threats. In other words, by reducing susceptibility to reward, conservation might have promoted such adaptive disengagement from unattainable goals (Wrosch, Scheier, Miller, Schulz, & Carver, 2003). This reasoning resonates well with the idea that negative mood and depression, with the concomitant inertia in taking action, may be functional and adaptive when facing adverse events because they prevent further danger, losses, or pointless efforts (Nesse, 2000).

Interestingly though, the second study showed that this inhibition did not indiscriminately apply to all types of rewards. Specifically, heightened conservation reduced pupil dilation, a marker of reward sensitivity, only when viewing sex-related images but not when viewing food-related images, with the latter case stimulating a tendency toward increased pupil dilation. This finding suggested that only the pursuit of costly, energy-requiring rewards was inhibited by intense conservation needs. In contrast, restorative, energy-giving rewards, because they are compatible with the dominant motivation, appeared even more attractive. Compared to previous work (e.g., Giacomantonio et al., 2014), introducing the distinction between costly and restorative rewards can be considered an important step toward a more nuanced understanding of the motivational dynamics following self-regulatory exertion. The ability to predict different, sometimes opposite, reactions to rewards that are often considered as similar and interchangeable could help in reducing apparently inconsistent or obscure patterns of results.

An alternative explanation would suggest that when exertion of self-control is followed by a difficult task, individuals tend to refrain from arousing stimuli in general, regardless of whether they constitute rewards. We sought to address this issue preemptively by including images that were arousing but with lower (restorative) rewarding potential (i.e., erotic images of couples). The results, however, proved more nuanced. More specifically, while in absolute terms the erotic couples produced more arousal than the erotic singles, the former was unresponsive to our self-control exertion manipulation, while the latter was not. Indeed, the erotic single images functioned as a (costly) reward, and so, in the difficult math condition, were less desired (proxied by pupil dilation) after self-control exertion than after no-self-control exertion (and we found the opposite pattern for the food images). No such sensitivity to our manipulations occurred for the erotic couple images.

Hence, we can conclude that inhibition determined by intense conservation targets stimuli that are characterized by at least some rewarding potential with arousal being irrelevant. In sum, the present set of results sheds light
on the complex dynamics following self-control exertion, where at least two interdependent motivations coexist, which influence behavior in opposite directions and affect each other.

The critical reader may wonder whether the inconsistencies in our results, as well as the small effect sizes present a challenge to our claims. We acknowledge that in the present day, where the depletion-debate is ongoing and replication efforts and meta-analyses point to uncertainty about the robustness of the effects (Carter & McCullough, 2014; Lurquin et al., 2016), the present findings may not be seen as unequivocal evidence for the notions forwarded in the present investigation. Nevertheless, we want to highlight a few considerations. As recent research by Kenny and Judd (2017) shows, effects and effect sizes may fluctuate across studies and may decrease as a function of two sources of error: systematic and random. While systematic error points for example to the omission of a critical (moderator) variable as a source of null findings and small effect sizes, random error cannot be straightforwardly addressed. According to the authors, random error needs to be acknowledged as a “fact of life” in interpreting a series of effects and effect sizes. This suggests that for any given phenomenon, there is not one true effect size but rather a range of true effect sizes. This perspective highlights the need for additional replication of the present results: it may well be that further replication shows similar or near-similar effect sizes, suggesting systematic error, thus pointing to additional moderators. Effect sizes deviating from the present ones would suggest random error, making the present, modest effect sizes and inconsistencies less problematic.

In addition, in our view, the small effect sizes and inconsistencies may be viewed as part-and-parcel of the phenomenon itself. As a recent meta-analysis (Dang, 2018) has shown, to the extent that the depletion effect exists (and this particular meta-analysis suggests that it does, but see Hagger et al. (2016) for an opposite conclusion), the effect is small. Still, we feel that small effects are well worth studying and indeed are the bread and butter of interesting, innovative phenomena in (social) psychology (see Richard et al., 2003).

In addition to the effect-size debate, we acknowledge that there is an additional debate about significance thresholds. While some authors suggest that the field should return to stricter thresholds to establish significance (e.g., $p < .005$ rather than $p < .05$; Johnson, 2013), other scholars encourage to abandon the whole idea of using cutoff values for deciding whether an effect is “significant” or not and instead opt to treat and report statistical measures as continuous parameters, with similarly continuous, rather than dichotomous implications for deciding on the relevance and substantiveness of effects (Amrhein, Greenland, & McShane, 2019). While it may be too soon to take sides in the debate, we want to highlight a few observations that argue in favor of not prematurely ignoring or discarding less conservative $p$-values and small, subtle effects. First, while shifting $p$-value cut-off values to lower, more restrictive thresholds may seem intuitively compelling, we should keep in mind that (very) low $p$-values, such as those suggested by Johnson (2013), in and of themselves do not necessarily imply larger effect sizes. Indeed, as Sullivan and Feinn (2012) argue, effect size is independent of sample size - unlike statistical significance (and power), which are a function of both effect size and sample size. Thus, for example, a finding with a very large sample could produce a tiny $p$-value but also a tiny effect size. Second, in addition to the “natural fluctuation” of effect sizes as postulated by Kenny and Judd (2017), we are sympathetic to the notion forwarded by Lakens and Ett (2017). These authors note that, partly given the above, unless studies are excessively powered and/or effect sizes of the target phenomenon are known to be excessively large, performing multiple studies will substantially increase the likelihood of observing mixed results, some meeting, others exceeding, and still others failing to meet a pre-set $p$-value threshold. Thus, “when observed, [mixed results] often provide evidence for the alternative hypothesis, given reasonable levels of statistical power and an adequately controlled low Type I error rate” (Lakens & Ett, 2017, p. 875). This translates well to the present case, since our studies were adequately (although not excessively) powered, and ego depletion effects are known to have anything but excessive effect sizes. On the contrary, effect sizes are typically (very) small to modest (e.g., Dang, 2018). Against this backdrop, most of the arguments against viewing the present (mixed) findings as relevant appear unsuitable to be used as a straightforward diagnostic tool. In contrast, the arguments of Prentice and Miller (1992), who assert that small effect sizes can be informative and important in their own right, seem to have more relevance for the present case. Indeed, the small effects actually appear to signal that the impact of self-control on reward sensitivity is a function of two processes, albeit of opposite signs (thus tending to cancel each other out, reflected in a small or sometimes nonsignificant effect). That is, as the present research shows, while self-control exertion may sometimes lower sensitivity to energy-requiring rewards, it may simultaneously increase sensitivity to energy-conserving or -replenishing rewards. Merely discarding such an effect on the basis of a modest $p$-value and/or effect size would have obscured this fascinating underlying process from view. In sum, while we recognize that the present findings need to be cautiously interpreted, we feel they do shed new light on when and why self-control exertion may affect the trade-off between reward seeking and energy conservation.
The current research also speaks to the importance of considering not only whether a person previously exerted self-control but also the degree of self-regulatory effort. In this sense, mild and severe depletion might have profoundly different consequences (see also Vohs, Baumeister, & Schmeichel, 2012 for a similar conclusion). Based on our findings, we could expect that intense self-control exertion might increase conservation motivation and attractiveness of restorative rewards, whereas mild self-control exertion might leave the conservation need silent and attraction to costly rewards still possible. These distinct motivational postures might favor self-control failure in one domain (e.g., less persistence on a difficult task) but not in another domain (e.g., the tendency to approach a reward by taking risks or lying). It would be very difficult to understand these discrepancies if motivations and intensity of previous self-control exertion were not taken into account.

This line of reasoning also suggests that more attention should be paid to the tasks that are usually employed to determine self-control capacity. Delay of gratification, risk-taking, eating delicious food and persevering on an unsolvable task might vary depending on a variety of different influences to be considered interchangeable indicators of self-control. As our findings suggest, some of these outcomes might be differently affected by previous self-control exertion, depending on its intensity and, more importantly, by the predominant underlying motivational orientation (i.e., conserving resources vs. gaining rewards). Hence, researchers should bear in mind the specificity of each task with respect to the motivational mechanisms driving the self-control performance. In this sense, it would be helpful to consider motivation as the most proximal variable associated with self-control failure following previous exertion of self-control. Doing so could potentially contribute to reducing discrepant pattern of findings and, hopefully, to increasing replicability of results in this field. Indeed, more careful consideration of the intensity of the manipulation, as well as the type of behavior assessed (e.g., reward-seeking, inaction, lack of perseverance) might help to reconcile inconsistencies. Including the concepts of costly versus restorative rewards, or conflicting motivations following self-control exertion in the depletion model might improve the ability to make accurate predictions of resulting effects. For example, if valence of reward is not considered when designing a depletion study, one could be puzzled by the fact that a very intense manipulation designed to induce depletion does not produce the expected findings when (lack) of self-control is operationalized using a (costly) reward (e.g., cheating to get money). Nevertheless, the same manipulation could work when (lack) of self-control is examined with a behavior connected to conservation (i.e., lack of perseverance on unsolvable anagrams). Of course, improving theory considering the complex motivational dynamics should be not considered the only approach to deal with the issues of the field, but it could help to avoid “throwing the theoretical baby out with the methodological bathwater.” As noted by Lurquin and Miyake (2017), the literature on self-control and depletion is paying the costs of poor operational definitions of self-control and poor empirical validation of self-control tasks. We agree with this point of view and hope that keeping in mind the motivational processes underlying self-control (failure) will lead to a more solid and reliable conceptualization of this issue. It is not surprising, after all, that understanding how self-control exertion affects subsequent behavior is a particularly difficult task when the dominant goals, amount of effort, as well as the specific operationalizations, are not carefully considered.

References


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Authorship
The three authors conceived of the project, designed the study and analyzed the data. J. Jordan implemented and coordinated data collection of Study 1 and pilot of Study 2. M. Giacomantonio implemented and coordinated data collection of Study 2. All three authors contributed to the writing of the manuscript.

Open Data
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