The Propagation of Self-Control:

Self-Control in One Domain Simultaneously Improves Self-Control in Other Domains

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Mirjam A. Tuk *

Imperial College Business School

Rotterdam School of Management, Erasmus University

Kuangjie Zhang

Nanyang Business School, Nanyang Technological University

Steven Sweldens

Rotterdam School of Management, Erasmus University

INSEAD

Author Note

* Mirjam A. Tuk (m.tuk@imperial.ac.uk) is assistant professor of marketing, Imperial College Business School, Exhibition Road, London, SW7 2AZ, UK and visiting professor at the Rotterdam School of Management, Erasmus University. Kuangjie Zhang (kjzhang@ntu.edu.sg) is assistant professor of marketing at Nanyang Business School,

Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798 and a research fellow at Institute on Asian Consumer Insight. Steven Sweldens (sweldens@rsm.nl) is associate professor of marketing at the Rotterdam School of Management, Erasmus University, Burgemeester Oudlaan 50, 3062 PA Rotterdam, The Netherlands and assistant professor of marketing (on leave) at INSEAD. This research received financial support from the INSEAD R&D and the INSEAD Alumni Fund. We are grateful for the data collection assistance offered by the INSEAD Social Science Research Center, by the Erasmus Behavioral Lab at Erasmus University, and by Marieke van Berlo. We thank the editorial review team for their help and their encouragement of the New Statistics approach to data-analysis. Correspondence concerning this article should be directed to Mirjam A. Tuk, m.tuk@imperial.ac.uk.

Abstract

A rich tradition in self-control research has documented the negative consequences of exerting self-control in one task for self-control performance in subsequent tasks. However, there is a dearth of research examining what happens when people exert self-control in multiple domains simultaneously. The current research aims to fill this gap. We integrate predictions from the most prominent models of self-control with recent neuropsychological insights in the human inhibition system to generate the novel hypothesis that exerting effortful self-control in one task can *simultaneously improve* self-control in completely unrelated domains. An internal meta-analysis on all 18 studies we conducted shows that exerting self-control in one domain (i.e., controlling attention, food consumption, emotions or thoughts) simultaneously improves self-control in a range of other domains, as demonstrated by, for example, reduced unhealthy food consumption, better Stroop task performance, and less impulsive decision making. A subset of nine studies demonstrates the crucial nature of task timing – when the same tasks are executed *sequentially*, our results suggest the emergence of an ego depletion effect. We provide conservative estimates of the self-control facilitation (d = |0.22|) as well as the ego depletion effect size (d = |0.17|) free of data selection and publication biases. These results (i) shed new light on self-control theories, (ii) confirm recent claims that previous estimates of the ego depletion effect size were inflated due to publication bias, and (iii) provide a blueprint for how to handle the power issues and associated file drawer problems commonly encountered in multi-study research projects.

Keywords: self-control, multi-tasking, inhibitory spillover, ego depletion, internal meta-analysis, inhibition

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The human ability to exert self-control is a crucial determinant of adaptive functioning such as adherence to morals, laws, social norms and other rules and regulations. Successful self-control lies at the heart of mental and physical health, popularity, and professional and interpersonal success, whereas a lack of self-control increases susceptibility to undesirable behaviors such as eating disorders and drugs and alcohol abuse (Gailliot, Baumeister, et al., 2007; Tangney, Baumeister, & Boone, 2004). Self-control refers to people's ability to alter their behavioral tendencies to bring them in line with their long-term goals or standards. Due to its vast impact on a wide variety of human behaviors, self-control is studied in multiple subfields of psychology. For example, neuropsychologists aim to gain a deeper understanding of the neural correlates of self-control exertion (J. D. Cohen, Botvinick, & Carter, 2000; J. R. Cohen & Lieberman, 2010); health and clinical psychologists are interested in how people cope with negative emotions and try to resist the lure of unhealthy foods and other substances (Davis, Patte, Curtis, & Reid, 2010); social psychologists study how self-control shapes the dynamics of interpersonal interactions (Gailliot, Plant, Butz, & Baumeister, 2007; Johns, Inzlicht, & Schmader, 2008), and cognitive psychologists investigate how self-control influences working memory span or response inhibition (Schmeichel, 2007).

A prominent field of research has focused on understanding the dynamic nature of self-control performance. Over 100 studies in various subfields of psychology, neuroscience, behavioral economics and consumer behavior have demonstrated that exerting self-control at time 1 leads to reduced self-control at time 2 (for a review and meta-analysis see Hagger, Wood, Stiff, & Chatzisarantis, 2010; Inzlicht, Schmeichel, & Macrae, 2014). This research stream is largely informed by the '*limited resource model'* (aka the 'strength model') of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister, Vohs, & Tice, 2007), which argues that all acts of self-control draw from a common and limited pool of mental energy. Depleting this resource by exerting self-control in one task will result in a temporary decline in self-control in other tasks – an effect commonly referred to as *ego depletion*. Despite its intuitive appeal, however, the lack of evidence for a limited resource as the underlying process led Inzlicht and colleagues to propose an alternative, non-resource-based '*process model of self-control depletion*' (Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014), which assigns a central role to a shift in people's motivation between task priorities.

Irrespective of the debate about the underlying psychological process, this stream of research has unquestionably deepened our understanding of sequential self-control dynamics. However, the question of how people cope with *simultaneous* self-control conflicts has received limited research attention. This is unfortunate for two major reasons. First, multi-tasking is of central importance in contemporary society. An ever increasing number of temptations present multiple challenges to people's self-control simultaneously. For example, self-control in the social domain (e.g., controlling one's emotions during a movie) can coincide with self-control in food consumption (e.g., resisting popcorn), just as attention control (e.g., avoiding distracting banner ads while browsing the internet) can coincide with self-control in decision making (e.g., resisting impulsive online purchases). Yet insights on the consequences of exerting self-control simultaneously in different domains are glaringly absent from the literature.

Second, investigating what happens when people exert self-control in multiple domains simultaneously may shed light on the psychological processes underlying self-control. Both the limited resource model and the process model focus primarily on explaining sequential self-control dynamics. While assuming different underlying processes, essentially both models predict that self-control will diminish at time 2 after being exerted at time 1. However, as we will outline below, extending the models to situations where people exert self-control in multiple domains simultaneously (both at time 1) allows diverging predictions to emerge.

Theoretical Framework

Self-control is defined as the human ability to inhibit automatic, habitual, or innate behaviors, urges, emotions or desires that would otherwise interfere with goal-directed behavior (Muraven, Shmueli, & Burkley, 2006). While people can employ various self-control strategies (e.g., avoiding temptation altogether, Fujita, 2011), when temptation is encountered, self-control reflects a struggle between impulses and desires on the one hand and inhibitory forces on the other hand (Hofmann & Van Dillen, 2012). Inhibitory control helps people to restrain impulsive response tendencies and allows for other responses in line with their long-term goals (Diamond, 2013; Hofmann, Schmeichel, & Baddeley, 2012; Inzlicht et al., 2014; Schmeichel, 2007).

In the last decade, research on self-control and self-control dynamics has been strongly influenced by the limited resource model (or strength model) of self-control (Baumeister et al., 1998; Baumeister et al., 2007; Muraven et al., 2006), which posits that all effortful, non-habitual acts of self-control draw from a common but limited energy resource. Note that only effortful acts of self-control are assumed to deplete the limited resource, while effortless acts of self-control (e.g., physiological forms of control such as regulating body temperature or heart rate variability) should operate independent of the limited resource (Baumeister et al., 2007). Depletion of the resource by an initial act of self-control will result in performance deterioration when subsequent self-control challenges are encountered. Indeed evidence abounds that exerting self-control in a wide variety of tasks, ranging from emotion control, thought control, and attention control to food consumption control, has detrimental consequences for subsequent self-control in an equally wide range of domains (Hagger et al., 2010).

Although empirical work has focused on sequential task settings, the predictions of the limited resource model for simultaneous acts of self-control are relatively straightforward. That is, if engaging in effortful, non-habitual self-control tasks uses up limited resources, then we would expect a deterioration of self-control ability in unrelated domains irrespective of whether the self-control challenges are faced simultaneously or in sequence. In support of this notion, Muraven and Baumeister (2000) argued that “like other limited resource models (such as attention), the strength model predicts that *simultaneous* attempts at self-control […] may lead to poorer self-control overall” (p.249, italics added; see also Kaplan & Berman, 2010 for similar predictions).

If, as some researchers have argued, it takes time for the limited pool of self-regulatory resources to become depleted (Vohs & Faber, 2007), then simultaneous efforts of self-control may suffer less from the resource limitation than those sequentially encountered. But either way, a limited resource model would never predict an increase in self-control ability for simultaneously encountered self-control challenges.

While evidence for the detrimental effect on sequential tasks has accumulated over the last decade, empirical support for the limited resource view as the underlying process is scarce and is treated with increasing skepticism (see Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014 for a review of the major critiques of the strength model). Inzlicht and colleagues proposed a more mechanistic process model to explain ego depletion effects. According to this process model, the refractory period of self-control is the consequence of an evolutionary process that allows organisms to balance their desires for exploitation and exploration, which translates into a tendency to seek a balance between externally rewarded labor and inherently rewarding leisure. They argue that, at time 1, people experience a motivation for ‘have-to’ tasks and exert self-control, after which they experience a temporary reduction in 'have-to' motivation at time 2 and an increased motivation for 'want-to' tasks which are personally enjoyable and meaningful. This shift in motivation allows them to engage both in exploiting established sources of reward and exploring the environment for new opportunities of reward. It prevents them from becoming preoccupied with one source of reward and allows for the sampling of other opportunities. According to the process model, it is this shift in motivation, attention, and emotion away from 'have-to' tasks towards 'want-to' tasks that makes people more likely to give into temptation at time 2, which lies at the heart of the ego-depletion effect.

The process model (Inzlicht & Schmeichel, 2012; Inzlicht et al., 2014) has focused on explaining the ego-depletion effect in sequential task settings, and the question is what the model would predict for simultaneous acts of self-control. To answer this question, we need to consider more precisely what happens when people engage in a 'have-to' task requiring self-control. Whereas self-control conflicts are often conceptualized as a choice between an impulsive option (e.g., a chocolate cake) and a controlled option (e.g., an apple), engaging in a 'have-to' task will often require the inhibition of not one but several different impulses. Consider, for example, what happens when one engages in a 'have-to' task at work, such as writing a report. This requires continuous control of attention (e.g., not being distracted by favorite websites, colleagues down the hall or incoming emails), as well as of emotions (e.g., frustration with an unproductive colleague) and of thoughts (e.g., about the upcoming weekend or ruminating over an argument with your partner earlier). Hence succeeding at 'have-to' tasks will require the inhibition of not just one, but many different impulses that could interfere with task performance. While captured in the definition of self-control (as the human ability to inhibit automatic, habitual, or innate *behaviors, urges, emotions or desires* that would otherwise interfere with goal directed behavior; Muraven et al., 2006), the fact that successful self-control often requires control over all of these impulses at the same time has been insufficiently considered in the literature. The crucial question is: Are humans equipped with the ability to inhibit multiple impulses at the same time?

Recent insights into the neuropsychological underpinnings of self-control suggest that this might indeed be the case. As noted earlier, response inhibition lies at the core of successful self-control (Diamond, 2013; Hofmann et al., 2012; Inzlicht et al., 2014). It has been proposed that inhibition of responses in a wide variety of domains originates from a single neural network. While various forms of response inhibition may seem vastly different (e.g., inhibiting affective, cognitive or motor impulses), they all depend on a few tightly-linked neurological areas, including the ventromedial prefrontal cortex, the lateral prefrontal cortex and the anterior cingulate cortex; together known as the “inhibitory network” (Aron, Robbins, & Poldrack, 2004; Berkman, Burklund, & Lieberman, 2009; J. R. Cohen & Lieberman, 2010; Heatherton, 2011; Heatherton & Wagner, 2011; Tabibnia et al., 2011).

Importantly, Berkman and colleagues (2009) proposed that if inhibitory signals for such a wide variety of tasks originate in the same areas of the brain, it is possible that inhibitory signals are not completely domain specific. Rather, recruiting the inhibitory network to intentionally inhibit one response may simultaneously facilitate response inhibition in unrelated domains, a phenomenon referred to as “inhibitory spillover.” Initial support for inhibitory spillover at the neurological level was provided by Berkman and colleagues who found that the intentional inhibition of a motor response (in a go/no-go task) resulted in the unintentional inhibition of simultaneously occurring emotional responses in the amygdala, an effect mediated by the activation of the inhibitory network in the right prefrontal cortex.

Further support for this theory was provided by Tuk, Trampe and Warlop (2011), who examined the impact of a visceral state on behavioral inhibition. They argued that increasing levels of bladder pressure require stronger inhibition signals to prevent a voiding impulse, which – according to the inhibitory spillover hypothesis – should increase response inhibition in unrelated domains. These authors found that higher levels of urination urgency correlated positively with performance on the Stroop task and increased intertemporal patience in a delay discounting task.

Whether or not inhibitory spillover plays a significant role in the effortful self-control tasks studied in the 100-plus articles that followed Baumeister et al's (1998) seminal article is, however, not a priori clear. As indicated, evidence for inhibitory spillover is limited to the neurological level (Berkman et al., 2009) or collected in the context of a highly learned and automatized visceral state (Tuk et al., 2011). These preliminary findings are susceptible to alternative explanations, such as devaluation effects or embodied willpower (Brendl, Markman, & Messner, 2003; Hung & Labroo, 2011) and cannot ex ante be generalized to the effortful, non-habitual self-control tasks considered in the self-control literature. As outlined above, it is exactly for these effortful self-control tasks that the limited resource model would predict a decline in performance on a second task irrespective of task timing.

Conversely, reasoning based on the process model and inhibitory spillover would suggest a rather different outcome when multiple self-control tasks are faced simultaneously. According to the inhibitory spillover hypothesis, when people engage in a 'have-to' task and inhibit a focal impulse, this should facilitate the inhibition of other impulses as well. Hence, self-control in unrelated domains will benefit and people become less impulsive. Therefore, the primary aim of the current research is to examine whether exerting intentional, effortful self-control in one domain facilitates *simultaneous* self-control performance in unrelated domains.

Berkman and colleagues (2009) found that inhibitory spillover effects at the neurological level were limited to the time window in which control was exerted in a primary task. Specifically, their results showed that amygdala activation was only suppressed during those trials in a go/no-go task where a motor response had to be inhibited, but not during intermediate trials. Hence if the self-control facilitation effect we expect to observe is the consequence of a spillover of inhibitory signals, then it should be limited to the time window in which control is exerted on the primary task. We thus hypothesize that the timing of the self-control tasks (simultaneous vs. sequential) constitutes a crucial moderator of whether the inhibitory spillover versus the ego-depletion effect will be observed.

We will examine the impact of exerting self-control in one domain on simultaneous versus sequential self-control performance in an unrelated domain in a subset of studies. By showing both an inhibitory spillover effect (for simultaneous self-control tasks) and an ego depletion effect (for sequential self-control tasks), we aim to provide converging evidence for the crucial role played by task timing. Finding both effects with the exact same tasks would also rule out alternative explanations for a self-control facilitation effect caused by specific task characteristics such as an increase in cognitive control as a consequence of response conflict similarity (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Dang, Dewitte, Mao, Xiao, & Shi, 2013; Dewitte, Bruyneel, & Geyskens, 2009). Finally, while it is not our primary aim here, testing the emergence of the ego depletion effect under sequential task settings with a variety of different paradigms also answers recent calls for more replication studies of the ego depletion effect in order to provide more accurate estimates of its effect size and confidence interval (Carter & McCullough, 2013; Hagger & Chatzisarantis, 2014).

Study Approach

To provide evidence for our proposition that exerting self-control in one domain simultaneously facilitates self-control in other unrelated domains, we borrow our general experimental approach from the ego depletion literature. Specifically, we opted for a multi-study approach using a wide variety of the most well-known independent variables (IVs) and dependent variables (DVs) from the ego-depletion literature (e.g., attention control, emotion control, control of unhealthy food consumption, impulsive decision making and Stroop task performance; see Hagger et al. (2010) Appendix A for numerous references to these tasks in the ego depletion literature). Where our research departs from previous work is that we administered these tasks simultaneously rather than sequentially. To demonstrate the existence of a domain-unspecific inhibitory spillover effect, finding convergence across a variety of paradigms was considered more informative than any single experiment could be.

A recurring problem with the multi-study approach is that individual studies fail to reach the conventional significance threshold level of $p < .05$. A strong reliance on null-hypothesis testing results in a dichotomous decision for each individual study as “succeeded” ($p < .05$; the study is reported, potentially after having applied researchers’ degrees of freedom in data collection and analysis; Simmons, Nelson, & Simonsohn, 2011) or “failed” ($p > .05$; the study often ends up in a file drawer; Ferguson & Heene, 2012; John, Loewenstein, & Prelec, 2012; Rosenthal, 1979; Spellman, 2012). One of the consequences of this ‘publication bias’ is an inflation of effect size estimates, resulting in uncertainty with regard to whether a published phenomenon can be considered a “real” effect at all (Schimmack, 2012; Simonsohn, Nelson, & Simmons, 2014). For example, some authors have argued that the effect size of the ego depletion effect (estimated at Cohen’s $d = 0.62$ based on a meta-analysis of all published ego depletion studies by Hagger et al., 2010) has been seriously inflated, potentially as a consequence of publication bias. Carter and McCullough (2013, 2014) estimate its true effect size at a maximum of $d = 0.25$, depending on the method used to correct for publication bias (see Hagger & Chatzisarantis, 2014, for a response to this analysis). This problem is not confined to the self-control literature (Bakker, van Dijk, & Wicherts, 2012).The reliance on null-hypothesis testing for evaluating individual studies has also been criticized based on the enormous variation in *p*-values, even between exact replications (Cumming, 2014). In fact, the chance of finding a significant difference in a two-cell design with 25 participants per cell and an effect size of $d = 0.30$ is only 18% (Braver et al., 2014).[1] One's chances of obtaining significance in both the original study and an exact replication are then as low as 3%.

The literature suggests a range of approaches to overcome this pitfall. Beyond traditional approaches such as removing (statistical) outliers in individual studies or significantly increasing sample size[2], it has recently been suggested that internal meta-analysis constitutes a sound approach to overcome power problems common to the multi-study approach (Braver, Thoemmes, & Rosenthal, 2014; Cumming, 2014; Maner, 2014; Schimmack, 2012; Stanley & Spence, 2014). The crucial insight offered by these authors is that even though individual studies might fail to reach the $p < .05$ criterion, they could nevertheless provide more (rather than less) evidence for the existence of an effect. By pooling data of various studies (with homogeneous effect sizes) the power level of the significance test increases and the confidence interval of the effect size estimate narrows. As a consequence, pooling the data of a series of replications ultimately results in a high probability of finding significance if an effect exists, while the chances of accurately identifying a null effect also improve (Braver et al., 2014). In other words, both Type I and Type II error chances are reduced. The key idea is that, rather than providing conclusive evidence for the (non)existence of an effect, an individual study should be seen as an estimate of reality. A meta-analysis containing all these individual study estimates can provide more conclusive insights on the size of an effect, as well as the precision with which it is measured (i.e., the confidence interval).

Based on the above-mentioned considerations as well as our primary theoretical interest in the consequences of simultaneous self-control exertion in general, we present an internal meta-analysis of all 18 studies conducted for this research project. It should be noted that rather than using meta-analysis as a tool to provide a synthesis of the literature, we use meta-analysis as our primary method of analysis to examine the existence and size of the inhibitory spillover effect. The structure of the meta-analysis section is as follows: We start with a general description of our samples, details of our data collection procedures, manipulations, and dependent measures. After providing an overview of the experimental designs, we discuss the consequences of simultaneous self-control exertion, followed by a discussion of sequential self-control exertion. Then we test whether task timing serves the proposed moderating role. We will also discuss various indices of publication bias.

Method: Internal Meta-Analysis of 18 Studies

Overview and Participants

We tested the inhibitory spillover effect in a series of k = 18 different studies, with 1695 participants in total. Two participants failed to follow crucial research instructions and we were unable to collect their data (the RA could not provide them with food in studies where food consumption was the crucial dependent variable). One participant was allergic to chips in a study where consumption of chips was the crucial dependent variable. This left 1692 valid observations, 1015 females and 677 males (age M = 28.4, SD = 10.3). Of these 18 studies, eight studies were conducted in the labs of three universities (n = 703) and 10 were conducted online (using Amazon's Mechanical Turk; n = 989). Participants in lab studies were primarily European, while participants in the online studies were mainly from the US (see Supplemental Online Material for study-specific details). The lab studies that required specific interactions with the participant (e.g., providing and removing food in studies that manipulated or measured food consumption control) were conducted by various RAs who were blind to our hypotheses and/or condition allocation. While there was no difference between online studies and lab studies in terms of gender composition (60.5% women in lab studies and 59.7% women in online studies, χ^2 = 0.74, p = .74), participants in the lab studies were slightly younger and more homogeneous in terms of age (M_{lab} = 22.24, SD_{lab} = 3.09 versus M_{online} = 32.77, SD_{online} = 11.35, $t(1186.7) = 27.76$, $p < .001$, Satterthwaite correction for inequality in variance).

Independent Variables

As we aimed to examine the consequence of exerting self-control in a wide variety of domains on simultaneous self-control ability in unrelated domains, we manipulated self-control exertion in five different domains – thought control (TC), attention control (AC), cognitive impulse control (CIC), consumption control (CC) and emotion control (EC). We aimed to measure self-control ability in an unrelated domain *while* participants were engaging in these various self-control tasks. We provide a general description of each manipulation below. Study-specific details can be found in the Supplemental Online Material.

Attention control. In five studies, we manipulated whether participants had to control their attention from being directed to distracting objects. Prior research suggests that focusing attention requires active inhibition of the impulse to attend to distracting stimuli (Diamond, 2013; Rueda, Posner, & Rothbart, 2011). This inhibition of attention shifts is known to result in a loss of self-control in sequential paradigms (see Hagger et al., 2010 for a reference to 24 studies showing depletion effects after various forms of attention control). Specifically, in three studies (Studies 4, 16, 17) participants in the attention-control condition were asked to focus attention on a woman instead of on words displayed at the bottom of the screen while watching a video (Gailliot, Baumeister, et al., 2007; Gilbert, Krull, & Pelham, 1988). Participants in the matched control condition did not receive such instructions and watched the video freely. Instead of measuring self-control ability after participants finished watching the video (as in previous research on ego depletion), we offered them various unhealthy foods (e.g., Pringles chips or M&M’s) for consumption *while* they were watching this video and controlling their attention.

In two studies (Studies 6 and 9) we manipulated attention control in an online setting. Participants were exposed to a banner ad on the top of their screen which consisted of five different ads, displayed for two seconds before automatically switching to the next ad. This nonstop change was implemented to ensure that attention was constantly drawn to this distractor and avoiding looking at the banner ads would continuously require effortful control of attention (Corbetta & Shulman, 2002). Participants in the attention-control condition were instructed to avoid looking at the banner ads by all means whereas participants in the control condition did not receive such instructions.[3] Simultaneous self-control ability was measured with brief self-control scenarios that were displayed on the same webpage.

Thought control. In nine studies we manipulated whether participants had to suppress unwanted thoughts (Wegner & Gold, 1995; Wegner, Schneider, Carter, & White, 1987; see Hagger et al., 2010 for references to 26 studies using thought suppression in the ego depletion literature). Thought control requires continuous inhibition of the "forbidden" thoughts (Diamond, 2013) and is known to result in a decline in self-control performance on tasks administered after the thought-control task. Participants in the thought-control present condition were asked not to think about a forbidden object (e.g., a white bear) during a 2-3 minute thought-listing task and to press a (bogus) button if they inadvertently happened to think about the forbidden object. Contrary to previous research on ego depletion, task simultaneity was imposed by instructing participants after the thought-listing task to *continue* not to think of the forbidden object while proceeding with the next task, which was a measure of self-control ability in an unrelated domain (e.g., delay of gratification or impulse control in a self-control scenario – see the "Dependent Variables" section for further details). The button that participants had to press if they inadvertently thought of the forbidden object remained present during this second task for participants in the thought-control present condition. Participants in the matched control conditions completed the same tasks but did not receive the thought-suppression instructions.

Cognitive impulse control. In one study (Study 12), we manipulated cognitive impulse control with the “crossing-out-letters task” (see Hagger et al., 2010 for a reference to 20 studies using this paradigm in the ego depletion literature). Participants in the cognitive impulse control condition were instructed to cross out all “e’s” unless there was another vowel immediately adjacent to it or one letter away from it. Participants in the matched control condition were instructed to simply cross out all “e’s” in a text. Participants were additionally instructed to indicate their preferences whenever they came across a choice in the target text. These were delay discounting questions. Hence, participants both had to cross the “e’s” in the question framing, and select the option of their preference at the same time.

In Study 7, cognitive impulse control was manipulated by means of an essay writing task (Muraven, Gagne, & Rosman, 2008; Muraven et al., 2006). Participants in the cognitive impulse control condition were instructed to avoid using the letters "à" and "â" while writing an essay in French (their native language), whereas participants in the matched control condition did not receive such instructions. Simultaneous self-control ability was assessed by measuring participants’ Pringles chips consumption while they were writing their essay.

Consumption control. In one study (Study 5), controlling consumption of unhealthy foods served as our independent variable. Participants started with a taste test and were provided with a bowl filled with Pringles chips. They were asked to take one chip, savor it and evaluate it. Then they continued with the next task (the Stroop task; Stroop, 1935). Participants in the consumption control condition were additionally instructed to avoid eating any more of the chips, while participants in the control condition were free to continue consuming chips if they wished. Performance on the Stroop task served as our measure of simultaneous self-control ability.

Emotion control. In one study (Study 15), we used another well-known paradigm from the ego depletion literature – the emotion-control paradigm (used in 23 studies testing the ego depletion effect; Hagger et al., 2010). Participants watched a 7-minute episode from the movie “City of God.” The episode contained both positive (a party with people celebrating) and negative (a fierce argument and a shooting) emotional aspects. Participants in the emotion-control condition were instructed not to feel or display any emotional reaction while watching this video clip, whereas participants in the matched control condition did not receive such instructions. Simultaneous self-control was assessed by serving tempting but unhealthy foods (Pringles) *while* participants were watching this episode.

Dependent Variables

We measured the impact of exerting self-control in one domain on simultaneous self-control ability in the following domains: Choice and volition (CV), unhealthy food consumption (UFC), unhealthy food consumption intentions (UFI), and cognitive impulse control (CIC). An overview of these categories of dependent variables and measurement scales is given below; details can be found in the Supplemental Online Material. For the meta-analysis all dependent variables were z-transformed in order to form a standardized index of impulse control.

Choice and volition. In 10 studies, self-control ability was measured in the broad domain of choice and volition. In two studies (Studies 1 and 12) self-control ability was assessed with a delay discounting task in which participants could choose between receiving a smaller amount of money (e.g., $67) tomorrow or receiving a larger amount of money (e.g., $85) later in time (e.g., 70 days from now; Li, 2008; Tuk et al., 2011). Our measure of impulse control is the number of times participants chose the delayed reward (ranging from 0 = always the immediate reward, to 8 = always the delayed reward). In general, people who prefer smaller amounts of a reward immediately are thought to be impulsive or to lack self-control, because they cannot control or inhibit their desire for an immediate payoff even though it would be beneficial in the long term to do so (J. R. Cohen & Lieberman, 2010).

In the other eight studies (Studies 2, 3, 6, 9-11, 13,14), we presented participants with various self-control scenarios, always depicting similar trade-offs between immediately gratifying options (e.g., going out with a friend; buying a nice pair of shoes on sale) and options that would be beneficial in the long term (e.g., studying for an important exam; saving a target amount of money; scenarios adapted from Hung & Labroo, 2011; Labroo & Patrick, 2009; Rook & Fisher, 1995). Self-control was typically assessed by asking participants what they would do in this situation (measured on 7- or 9-point scales where one extreme would reflect "definitely going for [the immediately rewarding option]" and the other extreme would reflect "definitely going for [the long-term beneficial option]").

Unhealthy food consumption. In five studies (Studies 4, 7, 15, 16, 17), our key measure of impulse control was the consumption of unhealthy food, a well-known measure of self-control ability in the ego depletion literature (see Hagger et al., 2010 Appendix A for a reference to 11 studies). Controlling the consumption of unhealthy foods requires the inhibition of the temptation to eat high-calorie, high-fat food (Inzlicht & Kang, 2010; Vohs & Heatherton, 2000). In four studies, participants were provided with a bowl filled with 20 Pringles chips. The number of chips eaten is considered a measure of impulsivity; hence the number of chips left over serves as our key measure of impulse control. In one study we provided participants with a bowl filled with 180 grams of M&M's and weighed the amount left over. In all studies the participant had to notify the RA (blind to our hypotheses and/or condition allocation) to start the primary self-control task (e.g., for starting the attention control movie or the emotion control movie). The RA then also provided them with the foods, told them that these were left-overs from another study, and that they could consume as much as they wanted. The participants had to notify the RA once they finished the primary self-control task, which allowed the RA to remove the foods when the participants stopped exerting self-control.

Unhealthy food consumption intentions. In Study 18 we measured consumption intentions towards unhealthy foods; in Study 8 we measured consumption intentions towards both healthy and unhealthy foods. Consumption intentions for healthy versus unhealthy foods serve as our measure of impulse control in the meta-analysis (Cornil & Chandon, 2013; Hedgcock, Vohs, & Rao, 2012). Impulsive intentions have frequently been used as a proxy of impulsive behavior and Hagger and colleagues' (2010) meta-analysis indicated no difference in effect size between behavioral and non-behavioral measures of the depletion effect.

Cognitive impulse control. In Study 5 we examined the influence of exerting self-control in one domain on impulse control in an unrelated domain with a classic measure of inhibitory control – the Stroop task (Hofmann et al., 2012; Stroop, 1935). In the Stroop task, participants are presented with a series of color words printed in various colors (e.g., the word "red" printed in blue). The task instructions alternately ask the participant to name the word itself or the color it is printed in. A response conflict only emerges when there is a mismatch between the word name and its color (the incongruent trials) and the incorrect response needs to be inhibited in order to state the correct response. Performance on this task is known to be subject to ego depletion effects in sequential settings. In line with previous work, response accuracy on the incongruent trials serves as our key measure of impulse control in the meta-analysis (Gailliot, Baumeister, et al., 2007; Gailliot, Schmeichel, & Baumeister, 2006; Job, Dweck, & Walton, 2010; see the Supplemental Online Material for further details).

Moderator: Simultaneous versus Sequential Self-Control

In the first set of nine studies, we only examined the consequences of exerting self-control in one domain on simultaneous self-control ability in unrelated domains. In the second set of nine studies (Studies 10-18) we also tested whether the ego-depletion effect would emerge if the same tasks were administered in sequence. It should be noted that our key comparisons always center around the differential impact of exerting self-control versus not exerting self-control in a focal task on self-control ability in an unrelated domain. Hence we never directly compare a condition where people exerted self-control simultaneously with a condition where people exerted self-control sequentially, as a difference between these two groups can be fully driven by an ego-depletion effect in the sequential task paradigms, an inhibitory spillover effect in the simultaneous paradigms, or a combination of both (as we expect). Only by comparing the impact of exerting self-control with not exerting self-control on simultaneous or on sequential self-control ability in an unrelated domain can we draw unequivocal conclusions about the emergence of an inhibitory spillover or an ego-depletion effect. This underlines the need to have control conditions that match as closely as possible to the various self-control conditions. Therefore, for each experiment that was intended to test the moderating impact of task timing, we carefully considered whether the specific experimental design allowed for one control condition (Studies 10-14), or whether two different control conditions (one matching with the simultaneous self-control condition and one matching with the sequential self-control condition) were required (Studies 15-18).

For example, the “white bear” paradigm and its variants allowed for one control condition, resulting in three conditions in total. In studies with this design, all participants were asked to engage in a thought listing task of 2-3 minutes. Additionally, two thirds of the participants (those in the simultaneous and sequential self-control conditions) were instructed to suppress all thoughts of white bears during the thought-listing ask, while participants in the matched control condition did not receive the thought-suppression instructions. The thought-listing task was followed by a measure of impulse control (e.g., a delay discounting task). Participants in the simultaneous self-control condition were additionally instructed to *continue* not to think of a white bear, while participants in the sequential self-control condition were told that they were free to think of anything from now on. Hence, for participants in the simultaneous self-control condition, the thought-suppression task *continued while* we assessed their impulse control in an unrelated domain. For participants in the sequential self-control condition, the thought-suppression task *ended before* their impulse control in an unrelated domain was assessed.

In Studies 15-18 we used two separate matched control conditions. As a consequence these studies had a 2 (self-control: present vs. absent) x 2 (task timing: simultaneous vs. sequential) design. For example, in Study 15 we used the emotion control paradigm. All participants saw a 7-minute video clip form the movie “City of God”. Participants in the self-control present conditions were instructed not to feel or display any emotions during this video, whereas those in the self-control absent conditions could watch the video freely. Additionally, half of the participants (in the simultaneous condition) received a bowl filled with Pringles chips together with this movie clip. The difference in Pringles consumption in this simultaneous condition between participants in the self-control present and the self-control absent conditions served as our measure of the inhibitory spillover effect. While the participants in the sequential conditions received similar emotion control instructions during the first clip, they did not receive a bowl of Pringles yet. Rather, they proceeded with a second video clip – a 7-minute video from the movie *Slumdog Millionaire,* resembling the previous clip in that it also contained both positive (people partying) and negative (a shooting scene) emotional aspects. Participants in the self-control present condition (who had controlled their emotions during the first clip) were told that they were free to experience and display emotions during the second clip. All participants in the sequential conditions were provided with a bowl of Pringles chips while watching this second video clip. The difference in Pringles consumption between participants who previously had controlled their emotions (in the self-control present – sequential condition) versus those who had not controlled their emotions (in the self-control absent – sequential condition) served as our key measure of the ego-depletion effect. Similar experimental designs were used with the attention-control video (Studies 16 and 17) and with the “old flames” paradigm (Study 18).

As a result, in the meta-analysis, participants in the control condition of the five 3-cell studies (studies 10-14, $n = 156$) feature both in the test of the inhibitory spillover effect and in the test of the ego-depletion effect, while Studies 15-18 had two different control conditions. Hence, we test the inhibitory spillover effect in simultaneous self-control conditions, where we had 624 participants in self-control conditions and 644 participants in matched control conditions. We test the ego-depletion effect in sequential self-control conditions, where we had 281 participants in self-control conditions and 299 participants in matched control conditions.

Additional Measures

In addition to our primary research aim to examine the consequences of simultaneous self-control exertion, we also measured a number of personality measures at the end of various studies. Since it has been suggested that there are interpersonal differences in human ability to inhibit responses and engage in inhibitory control, we considered it relevant to include measures that tap into these personality traits. Specifically, we measured sensitivity of the Behavioral Inhibition System and Behavioral Activation System with the BIS/BAS questionnaire or the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Carver & White, 1994; Gray & McNaughton, 2000; Nigg, 2000; Torrubia, Avila, Molto, & Caseras, 2001). We measured individual differences in executive inhibition with the Effortful Control scale (Rothbart, Ahadi, & Evans, 2000; Rothbart, Ellis, & Posner, 2011). We also included a dietary restraint measure in one study, using the Restrained Eating Scale (Herman & Polivy, 1980). The results of these interpersonal differences are not the core focus of our meta-analysis, and the key effects of individual differences in response inhibition are summarized in the Supplemental Online Materials.

Overview and Meta-Analytic Approach

We followed Cumming's recommendations in our meta-analytic approach (Cumming, 2012, 2014) and used Borenstein's Cumulative Meta-Analysis program for analyses (Borenstein, Hedges, Higgins, & Rothstein, 2009; www.meta-analysis.com). We computed the effect size and its 95% confidence interval for both the inhibitory spillover (number of studies $k = 18$) and the depletion effect ($k = 9$) in the individual studies by taking the mean differences and dividing them by the pooled standardized difference (Cohen's *d*). The difference scores were determined by subtracting the impulse control score in the matched control condition from the impulse control score in the inhibitory control condition. Hence, a positive effect size indicates an increase in impulse control as a consequence of exerting self-control in an unrelated domain relative to the control condition (i.e., an inhibitory spillover effect). A negative effect size indicates lower impulse control as a consequence of exerting self-control in an unrelated domain. In other words, a negative effect size confirms the presence of an ego-depletion effect. Because we used a wide variety of both IVs and DVs (the studies were conceptual rather than exact replications) and aim to generalize our results to self-control studies *in general*, a random effects model is most suitable (Borenstein et al., 2009; Valentine, 2012).

We report the Z-value testing the null hypothesis that the mean effect $\mu = 0$ (Rosenthal, 1979). In addition, the random effects model allows us to test the homogeneity of the effect sizes across studies, by means of the Q, I^2 and T^2 statistics. The Q statistic measures the total variability of the effect sizes between studies, weighted by the precision with which each effect size is measured. The Q statistic can be compared against a χ^2-distribution (with $df = k - 1$) to test whether there is significant heterogeneity in the effect sizes between studies. As the *Q* statistic is a relatively conservative test and can lead to Type II errors (accepting a set of studies as homogeneous while they have substantial heterogeneity), we increase the power of this test by raising its alpha level to .10 instead of .05 (Cumming, 2014). The I^2 and T^2 statistics are derived from *Q*. I^2 describes the degree of variability in effect sizes across studies, correcting for the number of studies included (contrary to the *Q* statistic). Hence the I^2 statistic can be compared between meta-analyses. An I^2 statistic of 25% suggests low levels of heterogeneity, 50% suggests moderate degrees of heterogeneity, and 75% indicates high levels of heterogeneity (Cumming, 2014; Higgins, Thompson, Deeks, & Altman, 2003). Finally, the T^2 statistic is an estimate of τ^2, which is the variance of the true effect size.

In addition to providing insights on the size of the inhibitory spillover effect and the ego depletion effect in our complete dataset, we explored whether the effects are moderated by study-specific characteristics. We first examined whether the size of the inhibitory spillover and depletion effect differs depending on whether the dependent measure is a measure of behavioral intentions or of actual behavior. To this end we coded our DVs as either a measure of behavior (consumption of various unhealthy foods such as Pringles or M&M's and Stroop task performance, $k = 6$) or as a measure of behavioral intentions (various self-control scenarios, intertemporal choices, and consumption intentions, $k = 12$) and analyzed whether this explains effect size heterogeneity across studies.

Second, we explored the different categories of self-control manipulations to see whether there are substantial differences in the size of the inhibitory spillover effect as a function of conceptually different manipulations of self-control (e.g., attention control, emotion control, cognitive impulse control, thought control and consumption control; due to the smaller number of studies we could not conduct this analysis for the depletion effect). Finally, we conducted a meta-regression to explicitly test the moderating role of task timing.

We performed these tests on our complete data-set, irrespective of the results obtained in the individual studies, without outlier removal or consideration of covariates. Hence it is to be expected that our effect size estimates will be smaller than those computed solely based on published studies (e.g., $d = 0.62$ for the depletion effect according to Hagger et al., 2010). Effect sizes based on published studies are inflated to the extent that the probability that an experiment is included in a meta-analysis is influenced by the results of that particular experiment (Carter & McCullough, 2013, 2014). Conversely, our approach presents a conservative, bias-free effect size estimate of both the inhibitory spillover and the ego-depletion effect, and in so doing heeds recent calls to provide more conclusive insights in the existence and strength of the ego-depletion effect (Hagger & Chatzisarantis, 2014). To provide evidence for the inclusion of all studies and data, we also discuss various indices for the detection of publication bias, notably the incredibility index of our results (IC-index, Ioannidis & Trikalinos, 2007; Schimmack, 2012), Begg and Mazumdar's Rank Correlation Test (Begg & Mazumdar, 1994), and Egger's test of the intercept (Egger, Smith, Schneider & Minder, 1997).

Results

The Inhibitory Spillover Effect

The averaged corrected standardized mean difference for the impact of exerting self-control in one domain on simultaneous self-control performance in an unrelated domain is $d = 0.22$, 95% CI [0.107, 0.334], $Z = 3.81$, $p < .001$. See Figure 1 for a Forest Plot of the effect sizes and confidence intervals of the individual studies and overall estimate. Post-hoc power computations show that the meta-analysis achieved a power of .97 to detect an effect of this size. This result confirms the presence of an inhibitory spillover effect, indicating that exerting self-control in one domain reliably increases self-control performance in unrelated domains. In addition, the Q statistic fails to reach the significance threshold of $p < .10$, $Q(17)$

= 17.73, p = .41 and the I^2 statistic is very low (4.1%). This indicates that the effect size estimates are homogeneous and that the large majority of the differences observed between individual studies are due to random sampling error, while only a very small proportion of the dispersion (4.1%) is due to real differences in effect sizes. This is further confirmed by T^2 = 0.002, which shows that the variance of the true effect size is very small. In other words, even though we used a wide variety of IVs and DVs, the experiments provide a homogeneous test of the inhibitory spillover effect. We also ran a jack-knifing procedure to examine whether any particular study had a relatively large impact by systematically removing one study at a time from the effect size estimation. The effect size ranged from d = 0.20, 95% CI [0.088, 0.319] when Study 9 was removed to d = 0.26, 95% CI [0.143, 0.375] when Study 7 was removed.

Next, we examined whether the inhibitory spillover effect is moderated by study-specific differences. We first investigated whether the inhibitory spillover effect differs in size depending on whether we measure behavior or behavioral intentions. The average effect size of the six studies using a behavioral measure of self-control is d = 0.20, 95% CI [-0.054, 0.456] and the effect size of the 12 studies measuring behavioral intentions is d = 0.24, 95% CI [0.109, 0.376]. Importantly, the Q statistic testing the between group variance is Q(1) = 0.08, p = .78. Hence there is no evidence that these two effect sizes differ in a systematic manner. We also checked whether there were systematic differences between online and lab studies, which is not the case, Q(1) = 1.32, p = .25.

Furthermore, we investigated whether the inhibitory spillover effect differs systematically in strength depending on the type of self-control (attention, emotion, thought, impulse or consumption control) exerted in the primary task. This analysis revealed considerable heterogeneity between these five different categories, as the between group variance is Q(4) = 11.13, p = .025 (see Figure 2 for a Forest Plot of the effect sizes and their confidence interval per category of self-control manipulation). Further investigation suggests that the studies in which cognitive impulse control was manipulated differ from the other four categories of manipulations, as evidenced by a (non-significant) negative instead of positive effect, d = -0.26, 95% CI [-0.578, 0.065], Z = -1.56, p = .12. The standardized residuals of the relative weight of both of these studies (-2.15 and -2.16) are larger than |1.96| which suggests that these studies can be considered outliers (Borenstein, 2015). Re-running the analysis with the four other categories of self-control manipulations while excluding the two cognitive impulse control studies reveals no systematic differences in the effect size estimates of the inhibitory spillover effect between the studies that employed an attention control, emotion control, consumption control or thought control manipulation, $Q(3)$ = 1.59, p = .66. The overall effect size estimate of these 16 remaining studies is d = 0.28, 95% CI [0.166, 0.402], Z = 4.71, p < .001. In sum, controlling thoughts, emotions, attention or unhealthy food consumption all facilitate simultaneous self-control ability in unrelated domains, in line with the inhibitory spillover hypothesis. Conversely, our manipulations of cognitive impulse control failed to improve self-control in unrelated domains, and self-control performance even slightly deteriorated when employing these paradigms. Potential conceptual differences between the cognitive impulse control studies and the other studies are reviewed in the General Discussion.

The Ego Depletion Effect

As a next step, we examined the presence of an ego depletion effect under sequential task timing. The averaged corrected standardized mean difference for the impact of exerting self-control in one domain on sequential self-control performance in an unrelated domain is d = -0.17, 95% CI [-0.356, 0.011], Z = 1.84, p = .066, confirming the presence of a marginally significant depletion effect (see Figure 3 for a Forest Plot of the study-specific as well as the overall effect size estimate). Contrary to earlier observations (Hagger et al., 2010), the ego depletion study effect sizes were homogeneous, $Q(8) = 9.85$, $p = .28$, $I^2 = 18.78$, $T^2 = 0.015$. Hence, similar to the inhibitory spillover effect, the major differences in the ego-depletion effect sizes between studies are the consequence of random sampling error, while only 18.8% of the dispersion is due to real differences in effect sizes, which is considered a 'small' proportion (Cumming, 2014). Post-hoc power computations show that the power of the meta-analysis to detect an effect of this size in this subset of studies is .53. However, it should be noted that there is some inherent circularity in *a posteriori* power computations as they are strongly dependent on the observed effect size. To illustrate, running a jack-knifing procedure on the studies employing the sequential task paradigm shows that the ego depletion effect size estimate ranges from $d = -0.12$, 95% CI [-0.317, 0.071] if Study 18 is removed from the dataset to $d = -0.24$, 95% CI [-0.409, -0.062] if Study 13 is removed. The corresponding power estimates vary tremendously, from .26 (based on $n = 473$ to detect $d = -0.12$) to .78 (based on $n = 519$ to detect $d = -0.24$). Conversely, an *a priori* power calculation would have indicated that our meta-analysis was *100%* powered to detect an ego depletion effect of the size reported in the literature ($d = |.62|$, Hagger et al., 2010)

There were no systematic differences between online and lab studies, $Q(1) = 0$, $p > .99$, nor between whether the variable of interest was a measure of behavior or of behavioral intentions, $Q(1) = 0.53$, $p = .47$.

The Moderating Role of Task Timing

To examine whether task timing (simultaneous vs. sequential) constitutes the crucial moderator between the inhibitory spillover and ego depletion effect, we conducted a random effects (method of moments) meta-regression with task timing as a contrast coded predictor. This analysis reveals that the effect size estimate of self-control performance under task simultaneity differs significantly from the estimate obtained under sequential task timing, $B =$

0.20, 95% CI [0.09, 0.30], $Z = 3.73$, $p < .001$, $Q(1) = 13.90$, $p < .001$.[4] Hence task timing constitutes a crucial moderator between the inhibitory spillover and ego-depletion effect.

Publication Bias

We aim to provide an estimate of the inhibitory spillover and ego-depletion effect sizes based on all the data obtained within the scope of this research project, without outlier removal, addition of covariates or any other data handling. In order to confirm the inclusion of all data collected, we discuss a number of publication bias indices. First, we examined the Incredibility Index (IC index; Ioannidis & Trikalinos, 2007; Schimmack, 2012). We computed the expected number of significant findings ($p \leq .05$; $k = 3.62$) based on the total power of all individual studies (computed based on the weighted average effect sizes of the inhibitory spillover and ego depletion effect) and compared that with the actual observed number of significant findings (based on $p \leq .05$, we identified four individual effect size estimates that can be considered significant) using a binomial distribution (Stat Trek, 2014). This probability is 50%, corresponding to an IC index of .50. This IC index is not close to the > .90 criterion that has been suggested as criterion to infer that there might exist more non-significant findings than have been reported (Ioannidis & Trikalinos, 2007; Schimmack, 2012).

As Schimmack (2012) warns that a low IC score is a necessary but not sufficient condition to ensure credibility, we also looked at two other indices of publication bias. Specifically, we computed Begg and Mazumdar's Rank Correlation Test (Begg & Mazumdar, 1994), which reflects the extent to which there is a relation between the standardized effect size (*d)* and its standard error (which is determined by sample size). The intuition is that effect sizes of studies with smaller samples have to be inflated more in order to reach significance, which leads to a negative correlation between the effect size and its standard error in cases of publication bias. To maximize the power of this test, we computed this correlation based on all 27 effect size estimates. As we expect a negative effect size for the sequential self-control tasks but a positive effect size for the simultaneous self-control tasks, we first recoded the effect sizes of the individual studies such that a hypothesis-consistent effect size received a positive sign and a hypothesis-inconsistent effect size received a negative sign (irrespective of the nature of the hypothesis). The correlation between the effect size estimates and their standard errors is not significant, Kendall's tau b = -0.009, p = .47 (one-tailed, as recommended).

To further confirm the absence of a systematic relationship between sample size and effect size, we also conducted Egger's test of the intercept (Egger et al., 1997). This test is a regression equation where the standardized effect (effect size divided by its standard error) is predicted with the precision (the inverse of the standard error). The key variable of interest is the intercept which is an indication of publication bias if it differs from zero. We conducted this analysis over the complete set of effect sizes, recoded as outlined above. This analysis confirms that the intercept of this regression model is not significant, B_0 = -0.24, $t(25)$ = 0.18, p = .43 (one-tailed). In sum, a variety of different tests pertinent to the identification of publication bias consistently show that there are no statistical indications that the reported dataset is a subset of a larger dataset.

General Discussion

For many years, self-control has been a core research topic in various subfields of psychology and related disciplines. Academic research has so far mainly focused on understanding self-control dynamics in sequential task settings, and the finding that exerting self-control at time 1 has a negative impact on self-control ability at time 2 has set the research agenda for over a decade. Yet everyday self-control challenges are often not faced in isolation. At work we must control the lure of entertaining websites, chats with colleagues and the candy jar all at the same time in order to be productive. In social settings we aim to stay focused on our interaction partner without being distracted by others or overindulging on tempting unhealthy food. Since existing self-control theories and empirical evidence are not unequivocal about whether and how simultaneously encountered self-control challenges may influence each other, our research seeks to fill this gap.

Based on recent advances in self-control theories combined with new neurological insights in the origins and nature of response inhibition, we argued that exerting self-control in one domain may simultaneously facilitate self-control performance in unrelated domains. In other words, we expected the ego-depletion effect to reverse under simultaneous task conditions. To provide evidence for our hypothesis, we deemed it appropriate to stay close to the general research tradition from the ego-depletion literature and test the effect in different settings and with different paradigms. We therefore adopted a multi-study approach and examined the consequences of exerting effortful, intentional self-control in one domain on simultaneous self-control ability in unrelated domains in 18 different studies utilizing a wide variety of well-known paradigms from the self-control literature.

However, we took a different approach in our data-analysis step and aimed to provide a conservative, data-selection bias free picture of the size and strength of the consequences of simultaneous (and sequential) self-control exertion. Following recent recommendations, we conducted an internal meta-analysis of all the data collected for this project (Braver et al., 2014; Cumming, 2014; Maner, 2014; Schimmack, 2012; Stanley & Spence, 2014). This greatly improves the power of the test of the inhibitory spillover effect and provides insights in the consistency of the results obtained across studies. It has been argued that such a meta-analytic approach is more tolerant to imperfections in the individual studies, but at the same time less susceptible to both Type I and Type II errors. It provides a much more accurate, clear and replicable portrait of empirical findings (Maner, 2014). We think that the current research provides a clear example of this point. If one looks only at the individual studies, without removal of any outliers or consideration of (relevant) covariates (e.g., hunger in studies where unhealthy food consumption was our crucial DV) and evaluates the results based on null hypothesis significance testing, the picture is not very clear (see the results of the individual studies in Figure 1). However, as Figure 1 reveals, almost all of the individual studies provide directional support for our hypothesis. By pooling the data collected for all individual studies, we were able to increase the power of the test to examine the inhibitory spillover effect from an average of 0.15 for the individual studies to 0.97 for the meta-analysis, and provide a reliable estimate of the effect size of the inhibitory spillover effect. The effect size is $d = 0.22$ with a 95% confidence interval of [0.107, 0.334], an estimate that is homogenous across a wide variety of conceptually different IVs (e.g., thought, attention, emotion, and consumption control) and DVs (e.g., impulsive decision making and unhealthy food consumption). The only manipulation of self-control that induced considerable heterogeneity in our overall effect size estimate was cognitive impulse control. We discuss the conceptual differences between these various categories of self-control in the section on executive functioning below.

Importantly, the confidence interval of the inhibitory spillover effect does not include zero, and we therefore conclude that exerting self-control in one domain results in a general improvement in simultaneous self-control performance in a wide variety of unrelated domains. In addition to examining the consequences of simultaneous self-control, we aimed to provide empirical evidence for the crucial role of task timing (simultaneous vs. sequential) in a subset of nine studies. Our results confirm that the inhibitory spillover effect is bound to simultaneous self-control tasks, while they suggest the presence of an ego-depletion effect under sequential task settings. Remarkably, while the ego-depletion effect is one of the most frequently documented observations in the self-control literature, the confidence interval of our effect size estimate (at $d = |0.17|$, based on $n = 580$) just included zero (95% CI [-0.356, 0.011]) and is substantially lower than effect size estimates that appeared elsewhere (e.g., d = 0.62 as estimated based on the published literature; Hagger et al., 2010). It should be noted that our estimates are on the conservative side – we reported all our data without the removal of any outliers or addition of covariates. For the sake of interpretation, note that the effect size of the average difference in height between 15- and 16-year old girls is also around 0.20 (J. Cohen, 1977; a d = 0.50 would correspond to the height difference between 14- and 18-year old girls). Bakker et al. (2012) recently concluded that an average effect size of 0.37 across 13 meta-analyses in the psychological literature is still an overestimation, as 50% of these meta-analyses showed signs of publication bias. As such, it might be the case that our notion of what effect sizes to expect in psychological research is distorted as a consequence of publication bias. Carter and McCullough (2013, 2014) recently estimated the ego-depletion effect at a maximum around d = 0.25, which is at par with our findings. As such, our results confirm their suggestion that the ego depletion effect is substantially smaller than the published literature implies.

Implications for Theories on Self-Control and Response Inhibition

The current findings have important implications for research in the domains of self-control and response inhibition. Combining insights from neuropsychology and behavioral research in psychology, our research derives new predictions in a domain that is highly relevant for human functioning. Recent neuropsychological insights in the origins of response inhibition suggest that there is one neurological region – the inhibitory network – responsible for the inhibition of a wide variety of responses (J. R. Cohen & Lieberman, 2010). Notably, it has been suggested that recruiting this inhibitory network for the inhibition of one response could unintentionally facilitate response inhibition in unrelated domains – a phenomenon termed inhibitory spillover. So far, support for the inhibitory spillover hypothesis has been limited to the neurological level or obtained in the context of a highly learned, largely automatized physiological form of response inhibition – bladder control (Berkman et al., 2009; Tuk et al., 2011). While response inhibition lies at the heart of self-control exertion, whether or not the inhibitory spillover hypothesis has implications for the extensive literature on self-control in the behavioral domain had, perhaps surprisingly, not been investigated so far.

One reason for this lack of research attention might be that, based on the most prevalent model of self-control – the limited resource model – one could easily reach the opposite prediction: Exerting effortful self-control in one domain depletes the limited resource, leaving less available for other acts of effortful self-control. Without additional assumptions, the limited resource model does not make different predictions for simultaneous versus sequential acts of self-control (Kaplan & Berman, 2010; Muraven & Baumeister, 2000). As a result, theoretical reasons for expecting different outcomes for simultaneous as opposed to sequential acts of self-control have long been absent, which may also explain why there is such a dearth of research studying simultaneous self-control exertion.

Contrary to the predictions by the limited resource model, our studies consistently show that exerting self-control in one domain simultaneously *improves* self-control performance in unrelated domains. In addition, our findings show that the ego-depletion effect is bound to self-control tasks that are encountered in sequence. The fact that self-control improves when multiple acts of self-control are exerted simultaneously is not readily reconcilable with the notion of self-control as a limited resource.

Our findings complement the recently proposed process model of self-control depletion. Specifically, Inzlicht and colleagues (2012, 2014) argue that the ego depletion effect is the consequence of a shift in motivation and attention from ‘have-to’ tasks requiring self-control at time 1 to ‘want to’ tasks – tasks that are enjoyable and intrinsically rewarding – at time 2. The original goal of the process model was to provide a more mechanistic account of the ego-depletion effect in sequential settings. Conversely, the current research focused on what happens *while* people engage in a ‘have-to’ task, reasoning that successful performance on such ‘have-to’ tasks requires people to inhibit not just one but many different potentially interfering impulses at the same time. We argued that people may be equipped with this ability because the inhibition of responses is centrally organized. Consistent with this, we found that when people engage in a self-control requiring task, their self-control in other domains simultaneously increases.

However, this also brings us to an important limitation of the current work. While our research provides evidence for the breadth of the self-control facilitation effect under task simultaneity by showing its occurrence across a wide variety of IVs and DVs, the depth of our evidence for inhibitory spillover as the underlying process is limited and further research is called for. This research could investigate the circumstances and stimuli most strongly associated with the self-control facilitation effect and identify its boundary conditions. In addition, future research should shed more light on the role played by individual differences. While we investigated a number of inhibition-related individual differences, due to power limitations in those individual studies our findings did not sketch a clear picture in this regard.

In sum, the current findings suggest that a more complete understanding of self-control dynamics requires us to look beyond the ego-depletion effect found in sequential task settings. Gaining more insight on simultaneous self-control processes sheds new light on self-control dynamics and provides new input for self-control theories. The self-control facilitation effect found under simultaneous task conditions is difficult to explain from the limited resource perspective. In addition, the process model of ego depletion could evolve further by broadening its focus. Rather than primarily explaining changes that take place when switching from ‘have-to’ to ‘want-to’ tasks, it could also deepen our understanding of what determines self-control ability *during* ‘have-to’ tasks.

Implications for Executive Functioning

While we believe that our research is the first to examine the consequences of effortful self-control in multiple domains simultaneously, previous research has investigated the impact of multi-tasking on self-control. For example, Ward and Mann (2000) looked at the consequences of cognitive load on the consumption of high-calorie food and found that restrained eaters were more likely to overindulge when they were simultaneously memorizing a series of art slides. Shiv and Fedorikhin (1999) found similar effects. In addition, Hinson, Jameson and Whitney (2003) showed that memorizing a difficult number increases people’s impulsive decisions in the financial domain. Given that it has repeatedly been shown that inducing cognitive load has negative consequences for simultaneous self-control, how can the findings reported here be reconciled with this recurring observation? We believe the answer might be found in the kind of executive functioning required by these dual tasks.

It has been argued that executive functions lie at the heart of effective self-control exertion (Baumeister et al., 1998; Diamond, 2013; Hofmann et al., 2012; Schmeichel, 2007). There is general agreement on the existence of three components of executive functioning, namely (1) working memory capacity, (2) inhibition of prepotent responses, and (3) mental set shifting (Diamond, 2013; Hofmann et al., 2012; Miyake et al., 2000). These three components all contribute to self-control exertion in different ways, which may explain the difference between our findings and previous work in the domain of multitasking and self-control. Previous work mainly taxed the working memory component by giving people a string of digits or art slides to keep in mind. Working memory capacity plays an important role in self-control by allowing individuals to keep their long-term goals salient in mind and to monitor their current actions vis-à-vis these long term goals. Without the active representation of long-term goals, self-control is directionless and bound to fail (Hofmann et al., 2012). Consequently, taxing working memory reduces people's ability to keep their self-control goals in mind and as a result self-control performance will deteriorate.

In the current research, we aimed to focus on the inhibitory component of executive functioning. While we cannot rule out the possibility that the dual task structure in the simultaneous self-control conditions imposed some cognitive load on our participants, it seems unlikely that the manipulations taxed working memory to the same extent as memorizing a series of digits or art slides. We purposely tried to select tasks that primarily require response inhibition rather than taxing working memory. For example, attention control requires the inhibition of the impulse to attend to distracting stimuli (Rueda et al., 2011); emotion control requires the inhibition of natural emotions (Muraven & Baumeister, 2000); and consumption control requires the inhibition of a consumption impulse (Dewitte et al., 2009; Hofmann, Friese, & Roefs, 2009). In line with the notion of inhibitory spillover, we found that engaging in one task that requires response inhibition simultaneously facilitated response inhibition in unrelated tasks.

We believe that this research, together with previous work, shows that taxing the different components of executive functioning can have radically different consequences for self-control performance. Taxing working memory reduces people's ability to keep their long-term goals in mind and has detrimental consequences for self-control ability (Hinson et al., 2003; Shiv & Fedorikhin, 1999; Ward & Mann, 2000). Conversely, taxing the response inhibition component of executive functioning increases response inhibition in unrelated domains, which has a positive effect on self-control ability. Though speculative, this distinction might also provide a conceptual explanation for why we found an (insignificant) decrease in simultaneous self-control in the two studies in which we manipulated cognitive impulse control. It is possible that these two tasks (scratching certain "e's" while avoiding other “e’s” according to a pre-specified rule or writing an essay while avoiding the most common letters from one’s mother tongue) required relatively more working memory capacity as compared to the other self-control paradigms utilized.

While it has been suggested that executive functions cannot be deployed for various tasks simultaneously (Kurzban, Duckworth, Kable, & Myers, 2013), our research suggests that this might critically depend on the nature of the executive functioning component required for task performance. More research on the consequences of taxing different components of executive functioning is called for as the picture is arguably more complex. For example, the consequences of taxing working memory for impulsive behavior are not unequivocal, as recent research suggests that taxing working memory can also reduce reward sensitivity and the processing of appetitive stimuli (Van Dillen, Papies & Hofmann, 2013; Van der Wal & Van Dillen, 2013). In addition, future research should deepen our understanding of the third component of executive functioning – mental set switching. Recent research has indicated that this component also plays a crucial role in self-control and can determine whether self-control facilitation or depletion effects are observed in sequential task settings (Dang et al., 2013; Dewitte et al., 2009). In general, future research should shed more light on the precise role of the different components of executive functioning in simultaneous compared to sequential self-control tasks.

Conclusion

While the importance of self-control ability for everyday human functioning is widely acknowledged across different streams of literature, it has frequently been noted that there is an important ‘but’ to human self-control ability: its limited nature. The current findings provide a brighter outlook on self-control ability and show that exerting self-control in one domain can actually facilitate simultaneous self-control ability in unrelated domains. Therein our research not only provides a new perspective on the dynamics of self-control exertion and self-control theories, it also suggests that humans are more capable of dealing with the multitude of self-control challenges in contemporary society than has hitherto been assumed.

Footnotes

[1] All power estimates are obtained with the free software “G*Power 3.1.7”, downloaded from http://www.gpower.hhu.de/ (Faul, Erdfelder, Lang, & Buchner, 2007).

[2] While increasing sample size is an effective way of reducing the likelihood of observing an effect based on chance, it is exactly the previously mentioned uncertainty with regard to the “realness” and size of an effect that makes it problematic to determine how large a sample size should be in order to be “sufficiently” large. For example, in several of our studies we aim to detect an ego depletion effect, which according to the meta-analysis by Hagger et al. (2010) has an effect size of d = .62, obtained with an average of 27 participants per cell. Based on these numbers, the probability (power) to detect such an effect with a two-tailed test equals 61%. If, however, the true size of the ego depletion effect is closer to d = .20 as suggested by Carter and McCullough (2013, 2014), a rather different picture emerges. An experiment with 27 participants per cell would in that case only have a power of 11%. In order to obtain a power of 61%, one should increase the sample size tenfold to 252 participants per cell, and even to 394 participants per cell to achieve a power of 80% as recommended by Cohen (1977). This example illustrates (1) that even though increasing sample sizes improves the power of individual studies, without accurate estimates of effect sizes there is significant uncertainty with regard to how large the sample sizes should be in order to achieve a sufficiently powered study, and (2) that studying a potentially small effect in a multi-study context would require excessively large samples if one expects the (majority of the) individual studies to be significant.

[3] As this was a modification rather than a direct implementation of an existing paradigm, we included two manipulation checks when first using this paradigm. To make sure that the attention control instruction had the intended effect, we asked participants how hard they had tried not to look at the banner while reading the scenarios (1 = not at all; 7 = very much). We also asked whether they thought the presence of the banner had influenced their answers to the scenarios (1 = strongly disagree; 7 = strongly agree). Results confirmed that participants in the attention control present condition had tried harder to ignore the banner ads (M = 5.92, SD = 1.50) than participants in the attention control absent condition (M = 3.80, SD = 2.07), $t(70) = 5.00$, $p < .001$, $d = 1.17$. There was no difference in the extent to which participants thought the banner ads had influenced their responses to the scenarios, $t(70) = 0.04$, $p = .97$, $d = 0.01$, which was low in both conditions ($M_{control\ present}$ = 2.29, SD = 1.71 and $M_{control\ absent}$ = 2.27, SD = 1.50). This suggests that the attention control manipulation did not have a conscious effect on participants' responses to the self-control scenarios.

[4] One assumption of the meta-regression is that each effect size estimate is independent. This assumption is violated in the five studies which employed a 3-cell design and the observations in the control condition are used in the estimates of both the inhibitory spillover and the ego depletion effect. The consequence of assuming independence while there is a correlation is that the standard error of the difference is too large and the confidence interval too wide, reducing the likelihood of rejecting the null hypothesis (Borenstein et al., 2009). The reported test can therefore be considered a *conservative* test of the moderating role of task timing.

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Figure Captions

Figure 1

Forest plot and summary statistics for simultaneous self-control tasks (inhibitory spillover). Effect sizes and 95% confidence intervals for the individual studies (gray lines and boxes) and overall estimate (black diamond).

Figure 2

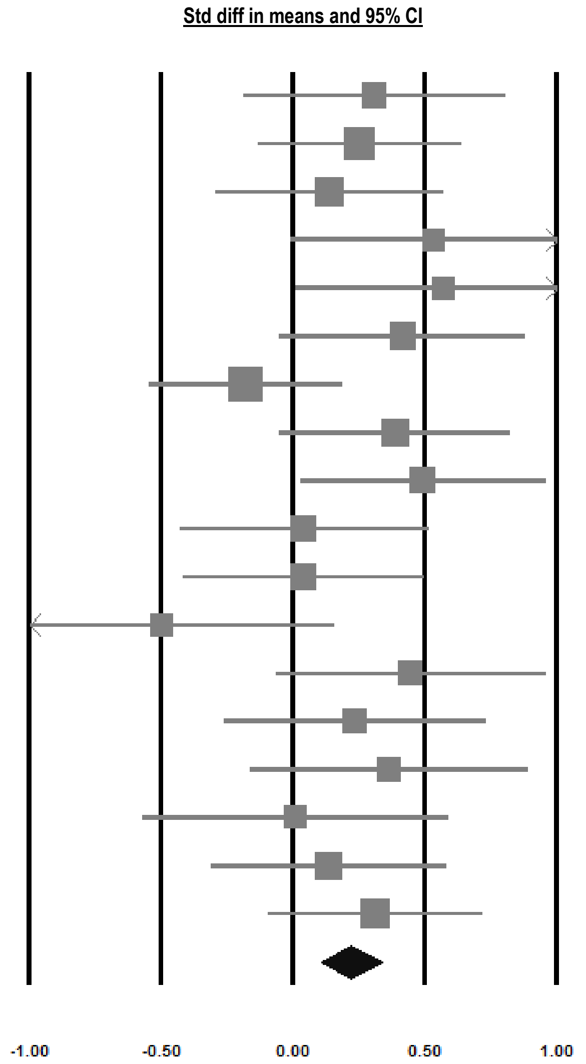
Forest plot and summary statistics (effect sizes and 95% confidence intervals) per category of self-control manipulation for the simultaneous self-control tasks.

Figure 3

Forest plot and summary statistics for sequential self-control tasks. Effect sizes and 95% confidence intervals for the individual studies (gray lines and boxes) and overall estimate (black diamond).

Figure 1.

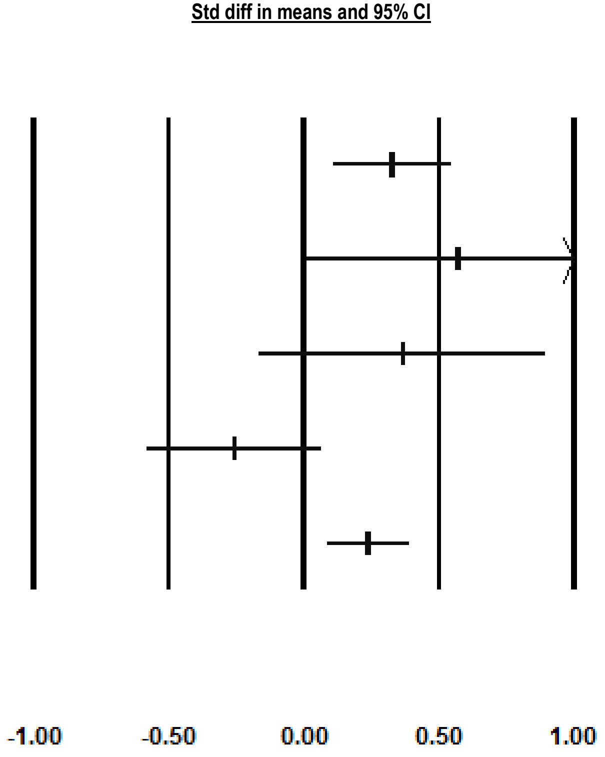
Study	IV	DV	n_d	Std diff in means (*d*)	Standard error	Variance	Lower limit	Upper limit	Z-Value	*p*-Value
Study 1	TC	CV	63	0.310	0.254	0.064	-0.187	0.808	1.223	0.221
Study 2	TC	CV	104	0.251	0.197	0.039	-0.135	0.637	1.276	0.202
Study 3	TC	CV	83	0.139	0.220	0.048	-0.292	0.570	0.634	0.526
Study 4	AC	UFC	54	0.534	0.277	0.077	-0.009	1.078	1.928	0.054
Study 5	CC	CIC	51	0.569	0.286	0.082	0.009	1.129	1.993	0.046
Study 6	AC	CV	72	0.414	0.238	0.057	-0.053	0.881	1.738	0.082
Study 7	CIC	UFC	113	-0.180	0.189	0.036	-0.549	0.190	-0.953	0.341
Study 8	TC	UFI	81	0.386	0.224	0.050	-0.054	0.826	1.721	0.085
Study 9	AC	CV	73	0.493	0.238	0.057	0.027	0.959	2.072	0.038
Study 10	TC	CV	69	0.041	0.241	0.058	-0.431	0.514	0.171	0.864
Study 11	TC	CV	74	0.039	0.233	0.054	-0.418	0.496	0.168	0.867
Study 12	CIC	CV	37	-0.498	0.334	0.112	-1.152	0.157	-1.490	0.136
Study 13	TC	CV	60	0.445	0.261	0.068	-0.067	0.958	1.704	0.088
Study 14	TC	CV	62	0.233	0.255	0.065	-0.266	0.733	0.915	0.360
Study 15	EC	UFC	56	0.365	0.269	0.073	-0.163	0.893	1.355	0.176
Study 16	AC	UFC	46	0.009	0.295	0.087	-0.569	0.587	0.029	0.977
Study 17	AC	UFC	76	0.135	0.230	0.053	-0.316	0.585	0.586	0.558
Study 18	TC	UFI	94	0.310	0.208	0.043	-0.097	0.717	1.492	0.136
Overall				0.220	0.058	0.003	0.107	0.334	3.809	0.000



Notes: The effect sizes in the forest plot are presented with masses reflecting the relative weight of that particular study in the meta-analysis (study weight is determined by the standard error of the observed mean difference). Positive effect sizes reflect an increase in self-control ability as a consequence of self-control exertion in an unrelated domain (inhibitory spillover); negative effect sizes reflect a decrease in self-control ability (ego depletion). n_d reflects the combined sample size of the inhibitory control and matched control conditions. Independent variables: AC = Attention Control; CC = Consumption Control; EC = Emotion Control; CIC = Cognitive Impulse Control, TC = Thought Control. Dependent variables: CV = Choice and Volition; CIC = Cognitive Impulse Control; UFC = Unhealthy Food Consumption; UFI = Unhealthy Food Consumption Intentions

Figure 2.

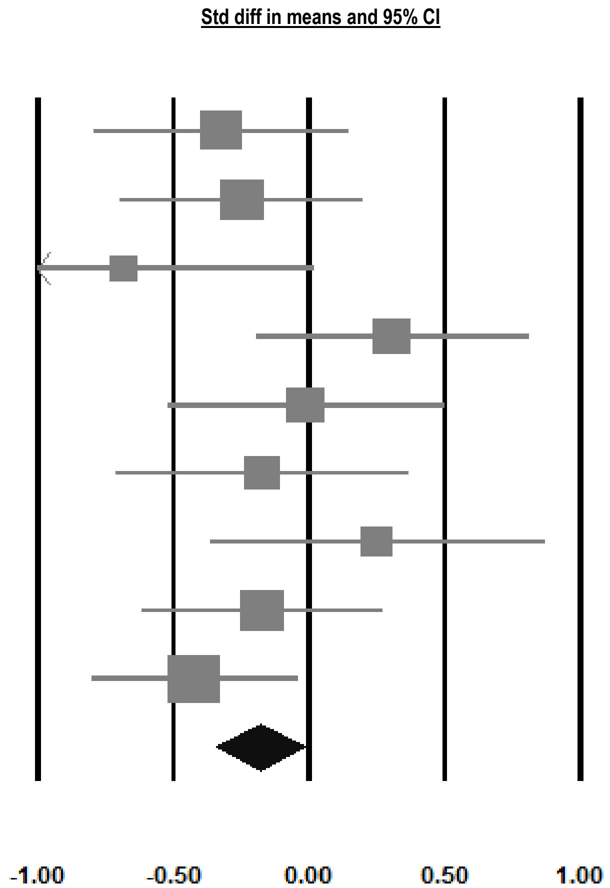
IV	Std diff in means (*d*)	Standard error	Variance	Lower limit	Upper limit	Z-Value	*p*-Value
Attention Control	0.325	0.113	0.013	0.104	0.546	2.886	0.004
Consumption Control	0.569	0.286	0.082	0.009	1.129	1.993	0.046
Emotion Control	0.365	0.269	0.073	-0.163	0.893	1.355	0.176
Cognitive Impulse Control	-0.257	0.164	0.027	-0.578	0.065	-1.562	0.118
Thought Control	0.238	0.077	0.006	0.088	0.388	3.106	0.002



Note: Independent variables: AC = Attention Control; CC = Consumption Control; EC = Emotion Control; CIC = Cognitive Impulse Control, TC = Thought Control

Figure 3.

Study	IV	DV	n_d	Std diff in means (*d*)	Standard error	Variance	Lower limit	Upper limit	Z-Value	*p*-Value
Study 10	TC	CV	71	-0.325	0.239	0.057	-0.793	0.143	-1.360	0.174
Study 11	TC	CV	77	-0.249	0.229	0.052	-0.697	0.200	-1.086	0.278
Study 12	CIC	CV	33	-0.684	0.360	0.129	-1.389	0.021	-1.901	0.057
Study 13	TC	CV	61	0.306	0.258	0.066	-0.199	0.811	1.188	0.235
Study 14	TC	CV	59	-0.011	0.261	0.068	-0.523	0.501	-0.042	0.967
Study 15	EC	UFC	53	-0.174	0.275	0.076	-0.714	0.365	-0.633	0.527
Study 16	AC	UFC	41	0.254	0.314	0.099	-0.363	0.870	0.807	0.420
Study 17	AC	UFC	78	-0.175	0.227	0.052	-0.620	0.270	-0.771	0.441
Study 18	TC	UFI	107	-0.423	0.196	0.038	-0.806	-0.040	-2.164	0.030
Overall				-0.172	0.094	0.009	-0.356	0.011	-1.841	0.066



Notes: The effect sizes in the forest plot are presented with masses reflecting the relative weight of that particular study in the meta-analysis (study weight is determined by the standard error of the observed mean difference). Positive effect sizes reflect an increase in self-control ability as a consequence of self-control exertion in an unrelated domain (inhibitory spillover); negative effect sizes reflect a decrease in self-control ability (ego depletion). n_d reflects the combined sample size of the inhibitory control and matched control conditions. Independent variables: AC = Attention Control; CC = Consumption Control; EC = Emotion Control; CIC = Cognitive Impulse Control, TC = Thought Control. Dependent variables: CV = Choice and Volition; CIC = Cognitive Impulse Control; UFC = Unhealthy Food Consumption; UFI = Unhealthy Food Consumption Intentions

Supplemental Online Material

Overview of Manipulations and Measures of the Individual Studies

Study Details	Inhibitory Control Manipulation	Impulse Control Measure	Effects Examined	Moderators
Study 1 *n* = 63 Online study US participants	**Thought Control** Avoid thinking of a white bear after just having seen a picture of a white bear during a 3 min. thought listing task *and* while indicating preferences on the intertemporal choices. (Wegner, Schneider, Carter, & White, 1987)	**Choice and Volition – 8 Intertemporal Choices** Which of the two options do you prefer at this moment? 1. receiving $10 tomorrow vs. receiving $12 in 25 days from now 2. receiving $67 tomorrow vs. receiving $85 in 70 days from now 3. receiving $34 tomorrow vs. receiving $35 in 43 days from now 4. receiving $48 tomorrow vs. receiving $55 in 45 days from now 5. receiving $40 tomorrow vs. receiving $70 in 20 days from now 6. receiving $16 tomorrow vs. receiving $30 in 35 days from now 7. receiving $30 tomorrow vs. receiving $35 in 20 days from now 8. receiving $15 tomorrow vs. receiving $35 in 10 days from now (Li, 2008; Tuk, Trampe, & Warlop, 2011)	Inhibition	BIS/ BAS
Study 2 *n* = 104 Online study US participants	**Thought Control** Avoid thinking of a panda after just having seen a picture of a panda during a 3 min. thought listing task *and* while indicating preferences on the 3 short scenarios (Based on Wegner et al., 1987)	**Choice and Volition – 3 Short Self-Control Scenario's** 1. You have planned a very nice trip with your friends this weekend. However, your parents are painting the house and could really use a helping hand. What would you do? (1- Definitely help my parents, 7-Definitely go on the trip; reverse coded) 2. You try to save a certain amount every month. However, you've just seen a great pair of shoes on sale. It's really a great deal, but you wouldn't be able to save your target amount if you bought them. What would you do? (1- Definitely buy the shoes, 7- Definitely save the money)	Inhibition	SP/ SR EC

		3. You are hungry and looking for a snack. You know taking a piece of fruit would be good for you. However, putting a ready-to-eat snack in the microwave would be much more tasty and satisfying. What would you do? (1- Definitely take the fruit, 7-Definitely take the snack; reverse coded)		
Study 3 *n* = 83 Lab study French and Dutch participants	**Thought Control** Avoid thinking of a white bear after just having seen a picture of a white bear during a 3 min. thought listing task *and* while indicating a preference for the scenario (Wegner et al., 1987)	**Choice and Volition – Self-Control Scenario** Pierre is reading his notes for his final exam. Pierre has been studying hard and has been over the material several times, but the final is known to be very difficult and the grade from this course is extremely important to Pierre. Pierre intends to major in this area and feels that his graduate school scholarship may be linked to doing well in this and other similar courses. Academic grades and doing well at college are very important to Pierre. Just then, his best buddy from high school, Jean, unexpectedly calls him on his cell phone. Jean lives in a different town far away and is visiting only for one night. Pierre has not met Jean in a long while and is unlikely to be meeting with him again anytime soon, because Jean is going away to college overseas. Pierre wants to catch up with his buddy, and Jean suggests coming over to Pierre's place for a few hours. Pierre knows that it will be fun to spend time catching up on old times. It’s already late in the evening, and Pierre wants to spend several more hours reading for his final. On the other hand, Jean and he go back a long way, and he really wants to spend the time with Jean. 1. If you were Pierre, how likely would you be to continue studying for the final? (1-Not at all likely, 7-Very likely) 2. If you were Pierre, what would you do? (1-Study for the final, 7-Spend the evening with Jean; reverse coded) (Hung & Labroo, 2011; Labroo & Patrick, 2009)	Inhibition	BIS
Study 4 *n* = 54 Lab study French participants	**Attention Control** Avoid looking at the words on the screen for a 6min video clip in which a woman is being interviewed by an off-camera interviewer (Gailliot et al., 2007; Gilbert, Krull, & Pelham, 1988)	**Unhealthy Food Consumption** A bowl with 20 Pringles chips was provided at the start of the video clip and removed at the end of the clip. Number of Pringles consumed served as our measure of impulse control. (Friese, Hofmann, & Wanke, 2008; Hofmann, Rauch, & Gawronski, 2007; Inzlicht & Kang, 2010)	Inhibition	BIS/ BAS

Study 5 *n* = 51 Lab study French participants	**Consumption Control** Inhibit the consumption of Pringles (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Vohs & Heatherton, 2000)	**Cognitive Impulse Control** Stroop Task – 4 blocks consisting of 25 trials each. In block 2 and 4, participants were instructed to indicate the meaning of the word on each trial. In block 1 and 3, participants were instructed to indicate the print color of the word on each trial. Participants could indicate their response by clicking on one of four buttons that appeared just below the target word (the buttons had a size of 2 x 0.6 cm each, shown 0.4 cm apart from each other, two buttons were presented next to each other and the other two appeared below them). The four different colors were written in black on these buttons. Each of these blocks contained both congruent (when the color word matched its print color) and incongruent trials (when the color word did not match its print color), presented in random order. Accuracy on incompatible trials (mismatch between color word and print color) served as measure of impulse control. (Gailliot, et al., 2007; Gailliot, Schmeichel, & Baumeister, 2006; Job, Dweck, & Walton, 2010)	Inhibition	X
Study 6 *n* = 72 Online study US participants	**Attention Control** Avoid looking at the banner ads on top of the screen while reading and answering the self-control scenarios (Based on Gailliot et al., 2007; Gilbert et al., 1988; see footnote 2 in the manuscript for manipulation check results)	**Choice and Volition – 2 Short Self-Control Scenario's** 1. You have planned a very nice trip with your friends this weekend. However, your parents are painting the house and could really use a helping hand. What would you do? (1- Definitely go on the trip, 7- Definitely help my parents) 2. You try to save a certain amount every month. However, you've just seen that the gorgeous jacket you've wanted for ages is now on sale. It's really a great deal, but you wouldn't be able to save your target amount if you bought the jacket. What would you do? (1- Definitely buy the jacket, 7- Definitely save the money)	Inhibition	SP/ SR
Study 7 *n* = 113 Lab study French participants	**Cognitive Impulse Control** Avoid the use of "à" or "â" while writing an essay in French (Mark Muraven, Gagne, & Rosman, 2008; Mark	**Unhealthy Food Consumption** A bowl filled with 20 Pringles chips was provided at the start of the essay task and removed at the end. Number of Pringles consumed served as our measure of impulse control.	Inhibition	BIS/ BAS SP/ SR EC

	Muraven, Shmueli, & Burkley, 2006)	(Friese, et al., 2008; Hofmann, et al., 2007; Inzlicht & Kang, 2010)		
Study 8 *n* = 81 Online study US participants	**Thought Control** "Old Flames Paradigm" Avoid thinking of a significant past relationship during a thought listing task after just having answered 10 questions about this relationship partner. Continue not to think of this relationship partner *while* indicating consumption preferences. (Wegner & Gold, 1995)	**Food Consumption Intentions – Healthy and Unhealthy Food** How many tomatoes/ grapes/ chips/ Skittles do you want to consume now? (1 = none, 5 = the entire bowl/pack). Pictures of each food item were provided. (Cornil & Chandon, 2013; Hedgcock, Vohs, & Rao, 2012)	Inhibition	BIS/BAS SP/ SR EC Restrained eating
Study 9 *n* = 73 Online study US participants	**Attention Control** Avoid looking at the banner ads on top of the screen while reading and answering the self-control scenario (Based on Gailliot et al., 2007; Gilbert et al., 1988)	**Choice and Volition – Self-Control Scenario** It is Friday evening and Patrick/Patricia [matched to the gender of the participant] has been looking forward to this evening a lot. He/She hasn't seen his/her friends for a while and has arranged to go to a concert with them. His/Her favorite band will play and he/she has bought the best tickets he/she could get a long time ago. It is a unique opportunity, as it is the first time his/her favorite band gives a concert in his city. He/She is really in the mood. Just then his/her mother calls him/her. His/Her parents are panicking a bit, because they just realized that today is the deadline to submit tax declarations, and they are completely lost in the complicated forms. Although a neighbor has offered his help, they feel uncomfortable about sharing such private information with the neighbor. His/Her mother asks whether Patrick/Patricia can come over tonight to help them with the taxes. Patrick/Patricia has a good relationship with his/her parents and know that they are always willing to help him. But he/she also realizes that it will take him/her the whole evening to help them. On the one hand, Patrick/Patricia has been really looking forward to this evening with his/her friends and to seeing the live performance of his/her favorite band. On the other hand, Patrick/Patricia values his relationship with his/her parents a lot, and knows how bad they will if they have to involve the neighbor.	Inhibition	SP/ SR EC

		1. If you were Patrick/Patricia, what would you do? (1- Definitely go to the concert, 9- Definitely help the parents) 2. If you were Patrick/Patricia, how likely would you be to go to the concert? (1- Very unlikely, 9- Very likely; reverse coded) 3. If you were Patrick/Patricia, how likely would you be to go to your parents? (1- Very unlikely, 9- Very likely) (Scenario based on Hung & Labroo, 2011; Labroo & Patrick, 2009. A pretest confirmed that this scenario reflects a self-control dilemma. Further details are available on request from the first author.)		
Study 10 *n* = 104 Online study US participants	**Thought Control** Avoid thinking of a white bear after just having seen a picture of a white bear during a 3 minute thought listing task. Participants in the inhibition condition were instructed to *continue* not to think of a white bear while answering the scenario. For participants in the depletion condition the thought control task ended before answering the scenario. (Wegner et al. 1987)	**Choice and Volition – Self-Control Scenario** Mary is a 21-year-old college student with a part-time job. It is two days before Mary gets her next paycheck and she has only $25 left for necessities. In addition to food, Mary needs to buy a pair of warm socks for an outdoor party this weekend. After work, she goes with her friend Susan to the mall to purchase the socks. As they are walking through Macy's, Mary sees a great looking sweater on sale for $75. Which one of the following purchase decisions do you think Mary will make? 1- she will buy the socks only 2- she will want the sweater but not buy it 3- she will decide not to buy the socks, and buy the sweater instead with a credit card 4- she will buy both the socks and the sweater with a credit card 5- she will buy both the socks and the sweater, plus matching pants and a shirt, also with a credit card (Rook & Fisher, 1995; Vohs & Faber, 2007)	Inhibition Depletion	BIS/BAS
Study 11 *n* = 111 Online study US participants	**Thought Control** Avoid thinking of a white bear after just having seen a picture of a white bear during a 3 minute thought listing task. Participants in the inhibition condition were instructed to *continue*	**Choice and Volition – Self-Control Scenario** Mary is a 21-year-old college student with a part-time job. It is two days before Mary gets her next paycheck and she has only $25 left for basic necessities. In addition to food, Mary needs to buy a pair of warm socks for an outdoor party this weekend. After work, she goes with her friend	Inhibition Depletion	BIS/BAS

	not to think of a white bear while answering the scenario. For participants in the depletion condition the thought control task ended before answering the scenario. (Wegner et al. 1987)	Susan to the mall to purchase the socks. As they are walking through Macy's, Mary sees that a gorgeous sweater she's wanted for ages is on sale. Instead of costing $120 it is now on sale for $75. Which one of the following purchase decisions do you think Mary will make? 1- she will only buy the food 2- she will buy food and the warm socks 3- she will buy food and the warm socks, and crave the sweater but not buy it 4- she will buy the food, but no socks, and will buy the sweater with a credit card 5- she will buy both the food and the socks, and will buy the sweater with a credit card 6- she will buy both the food and the socks, and the sweater, plus matching pants and a shirt, also with a credit card (Based on Rook & Fisher, 1995; Vohs & Faber, 2007)		
Study 12 *n* = 52 Lab study Dutch participants	**Cognitive Impulse Control** Cross out all the "e's" in two texts EXCEPT when it is adjacent to another vowel or one extra letter away from another vowel. For participants in the depletion condition, the crossing "e's" task ended *before* the intertemporal choices. Participants in the inhibition condition were instructed to cross out letters *while* also indicating a preference. Participants in the matched control condition were instructed to cross out all the "e's" without applying a rule. (Baumeister, et al., 1998; Muraven, 2008)	**Choice and Volition – 8 Intertemporal Choices** Which of the two options do you prefer at this moment? 1. receiving $10 tomorrow vs. receiving $12 in 25 days from now 2. receiving $67 tomorrow vs. receiving $85 in 70 days from now 3. receiving $34 tomorrow vs. receiving $35 in 43 days from now 4. receiving $48 tomorrow vs. receiving $55 in 45 days from now 5. receiving $40 tomorrow vs. receiving $70 in 20 days from now 6. receiving $16 tomorrow vs. receiving $30 in 35 days from now 7. receiving $30 tomorrow vs. receiving $35 in 20 days from now 8. receiving $15 tomorrow vs. receiving $35 in 10 days from now (Li, 2008; Tuk, et al., 2011)	Inhibition Depletion	BIS EC

Study 13 *n* = 91 Online study US participants	**Thought Control** Avoid thinking of kittens after just having seen pictures of kittens during a 3 minute thought listing task. Participants in the inhibition condition were instructed to *continue* not to think of kittens while answering the scenario. For participants in the depletion condition the thought control task ended before answering the scenario. (Based on Wegner et al., 1987)	**Choice and Volition – Self-Control Scenario** Jack is reading his notes for his final exam. Jack has been studying hard and has been over the material several times, but the final is known to be very difficult and the grade from this course is extremely important to Jack. Jack intends to major in this area and feels that his graduate school scholarship may be linked to doing well in this and other similar courses. Academic grades and doing well at college are very important to Jack. Just then, his best buddy from high school, John, unexpectedly calls him on his cell phone. John lives in a different town far away and is visiting only for one night. Jack has not met John in a long while and is unlikely to be meeting with him again anytime soon, because John is going away to college overseas. Jack wants to catch up with his buddy, and John suggests coming over to Jack's place for a few hours. Jack knows that it will be fun to spend time catching up on old times. It's already late in the evening, and Jack wants to spend several more hours reading for his final. On the other hand, John and he go back a long way, and he really wants to spend the time with John. 1. If you were Jack, how likely would you be to continue studying for the final? (1 - Very Unlikely, 9 - Very Likely) 2. If you were Jack, how likely would you be to spend the evening with John?(1 - Very Unlikely, 9 - Very Likely; reverse coded) 3. If you were Jack, what would you do? (1 - Study for the Final, 9 - Spend the Evening with John; reverse coded) (Hung & Labroo, 2011; Labroo & Patrick, 2009)	Inhibition Depletion	BIS/ BAS
Study 14 *n* = 89 Online study US participants	**Thought Control** Avoid thinking of kittens after just having seen pictures of kittens during a 3 minute thought listing task. Participants in the inhibition condition were instructed to *continue* not to think of kittens while answering the scenario. For participants in the depletion condition the thought control task ended before answering the scenario.	**Choice and Volition – Self-Control Scenario** Pat is on a diet to look attractive and keep healthy. Pat has an audition in two days and feels that the success of the audition may be linked to a successful diet. Also, her doctor has advised her that keeping on the diet is very important to her personal health. Just then, Pat's best friend from high school, Kate, unexpected calls her on her cell phone and invites Pat to her home. When you get there, Kate has spent a few hours in the kitchen preparing a very tempting chocolate cake, Pat's favorite. It's already late in the evening, and Pat wants to stick to her dieting goal. On	Inhibition Depletion	BIS/ BAS SP/ SR

	(Based on Wegner et al., 1987)	the other hand, Kate and she go back a long way, and she does not want to disappoint Kate. 1. If you were Pat, how likely would you be to eat the cake? (1 -very unlikely, 9 -very likely) 2. If you were Pat, how likely would you be to stick to the dieting goal and resist the cake? (1 -very unlikely, 9 -very likely) 3. If you were Pat, what would you do? (1 -stick to the dieting goal, 9 -eat the cake)		
Study 15 *n* = 109 Lab study Dutch participants	**Emotion Control** Inhibit any emotional reaction while watching a 6 min video clip. (Friese, et al., 2008)	**Unhealthy Food Consumption** A bowl with 20 Pringles chips was provided either the start of the first video clip and removed at the end of this clip (simultaneous conditions – aimed to test the inhibitory spillover effect), or at the start of a second video clip and removed at the end of this clip (sequential conditions – aimed to test the ego depletion effect). Number of Pringles left over served as our measure of impulse control. (Friese, et al., 2008; Hofmann, et al., 2007; Inzlicht & Kang, 2010)	Inhibition Depletion	BIS/BAS
Study 16 *n* = 87 Lab study French participants	**Attention Control** Avoid looking at the words on the screen for a 6min video clip in which a woman is being interviewed by an off-camera interviewer (Gailliot, et al., 2007; Gilbert, et al., 1988)	**Unhealthy Food Consumption** A bowl with 20 Pringles chips was either provided *during* the attention control task or immediately after the attention control task. Number of Pringles left over served as our measure of impulse control. (Friese, et al., 2008; Hofmann, et al., 2007; Inzlicht & Kang, 2010)	Inhibition Depletion	BIS/BAS
Study 17 *n* = 154 Lab study French participants	**Attention Control** Avoid looking at the words on the screen for a 6min video clip in which a woman is being interviewed by an off-camera interviewer (Gailliot, et al., 2007; Gilbert, et al., 1988)	**Unhealthy Food Consumption** A bowl with 180 grams of M&M's was either provided *during* the attention control task or immediately after the attention control task. Amount of M&M's left over served as our measure of impulse control. (Friese, et al., 2008; Hofmann, et al., 2007; Inzlicht & Kang, 2010)	Inhibition Depletion	BIS/BAS

Study 18 *n* = 201 Online study US participants	**Thought Control** "Old Flames Paradigm" Simultaneous conditions: Avoid thinking of a significant past relationship during a 2-minute thought listing task after just having answered 10 questions about this relationship partner. Continue not to think of this relationship partner *while* indicating consumption preferences. Sequential conditions: Avoid thinking of a significant past relationship during a 4-minute thought listing task after just having answered 10 questions about this relationship partner; free to think about anything when indicating consumption preferences afterwards Participants in the matched control conditions did not receive any thought suppression instructions. (Wegner & Gold, 1995)	**Food Consumption Intentions –Unhealthy Food** Imagine you would go for a drink/snack/dinner right now. How likely are you to choose a soft drink/candy bar/hamburger? (1 = very unlikely, 9 = very likely). Pictures of each food item were provided. (Cornil & Chandon, 2013; Hedgcock, et al., 2012)	Inhibition Depletion	BIS/BAS SP/SR EC

Notes: In a subset of studies (*k* = 9), we included the PANAS (Watson, Clark, & Tellegen, 1988) in order to check whether the self-control manipulation had inadvertently induced differences in mood, which was never the case (all *p*'s > .05). In studies where food consumption was our crucial variable of interest, we included two measures to control for individual differences in appetite. Specifically, we asked participants when they last ate before the experiment (1= just before the experiment, 7 = more than five hours before) and we asked them to indicate whether they last ate a full meal (breakfast, lunch, etc.) or a snack (cookie, candybar, etc.). Controlling for individual differences in appetite improves the power of the individual studies. We do not correct for individual differences in appetite in the meta-analysis.

Summary of Results – Individual Difference Measures

Sensitivity of the Behavioral Inhibition System. We examined whether the inhibitory spillover effect was moderated by interpersonal differences in motivational inhibition as measured with the BIS scale (Carver & White, 1994). Given the substantial homogeneity in the effect sizes of the inhibitory spillover effect across our studies, we pooled the data of all the studies containing the BIS questionnaire (k = 14, n = 966 observations to test the inhibitory spillover effect). We specified a regression model with a contrast code for the self-control conditions (0.5 for the inhibitory control present condition; -0.5 for the matched control condition), the standardized BIS score and their interaction as predictors of the standardized impulse control scores. Results revealed a significant simple effect of self-control condition, b^* = 0.074, t(962) = 2.32, p = .02 (i.e., the inhibitory spillover effect). In addition, there is a negative effect of BIS on impulse control, b^* = -0.10, t(962) = 3.11, p < .002, suggesting that people with a more sensitive BIS had on average lower levels of impulse control. Contrary to previous findings (Tuk et al., 2011), the interaction between self-control condition and BIS does not reach significance, b^* = -0.017, t(962) = 0.55, p = .58.

Next, we examined whether the inhibitory spillover effect is moderated by BIS as measured with the Sensitivity to Punishment (SP) subscale of the SPSRQ (Torrubia et al., 2001, k = 7, n = 599). A regression model with the contrast coded self-control condition, the standardized SP score and their interaction reveals similar effects to the ones reported above. Specifically, there is a significant simple effect of self-control condition on the standardized impulse control score, b^* = 0.116, t(595) = 2.86, p < .01 (i.e., the inhibitory spillover effect), as well as a significant and negative simple effect of SP on impulse control, b^* = -0.112,

$t(595) = 2.77$, $p < .01$. The interaction between self-control condition and SP fails to reach significance, $b^* = -0.03$, $t(595) = 0.82$, $p = .41$.

Executive Inhibition. While BIS reflects a relatively automatic, bottom-up inhibitory process, executive inhibition has been proposed to reflect a top-down, effortful form of control which is directly related to the human ability to inhibit a dominant response in order to perform a subdominant response (Rothbart, Ahadi, & Evans, 2011). Hence, motivational inhibition and executive inhibition are conceptualized as rather different forms of control. In line with the notion that people with low motivational inhibition might compensate with higher executive inhibition (Rothbart, Ellis, & Posner, 2000), we found a negative correlation between executive inhibition (measured with the Effortful Control (EC) scale) and BIS ($r = -.20$, $p < .001$, $n = 447$) as well as between EC and SP ($r = -.46$, $p < .001$, $n = 572$).

We examined whether the inhibitory spillover effect is moderated by EC ($k = 6$, $n = 502$). We specified a regression model with the contrast coded self-control condition, the standardized EC score and their interaction as predictors of the standardized impulse control score. Results reveal a marginally significant simple effect of self-control condition on the impulse control score, $b^* = 0.084$, $t(498) = 1.90$, $p = .057$ (i.e., the inhibitory spillover effect). While the simple effect of EC was not significant, $b^* = 0.046$, $t(498) = 1.04$, $p = .30$, the interaction between inhibitory condition and EC reached significance, $b^* = 0.088$, $t(498) = 1.99$, $p = .047$. To decompose this interaction, we used the Johnson-Neyman technique (Spiller, Fitzsimons, Lynch, & McClelland, 2013) to identify the range of Effortful Control scores for which the inhibitory spillover effect is significant. This analysis reveals that the inhibitory spillover effect passed the $p < .05$ criterion for 40% of our sample – those participants who scored 0.024 points or more above the mean EC score ($M_{EC} = 4.63$, $SD_{EC} = 0.79$, Johnson-Neyman point = 4.65, $p = 0.05$, 95% CI= [0.00, 0.35]).

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