Ego Depletion and Self-Control Failures: Resource Depletion or Changes in Motivation?

Abstract

Using self-control leads to ego depletion, a state whereby people are temporarily less successful at self-control. But the mechanisms underlying ego depletion remain debated. We tested the resource model (Baumeister, Vohs, & Tice, 2007) and motivation-based accounts of ego depletion (e.g., Inzlicht, Schmeichel, & Macrae, 2014). To manipulate resource depletion, participants (n = 78) initially completed either a non-depleting or depleting Stroop task. To test the role of motivation, we manipulated the Stroop task's perceived difficulty: participants within each Stroop condition were misled into believing that the task was either easy or difficult. Contrary to the resource model's predictions, participants who completed the depleting (vs. non-depleting) Stroop task did not perform worse on a second self-control task. But consistent with motivational-based accounts, those who believed the Stroop task was difficult (vs. easy) performed worse on the second task. No effect was observed on approach motivation. Taken together, our findings are more readily accommodated by motivational models. Future research should investigate the precise motivational mechanics underlying ego depletion.

Keywords: ego depletion, self-control, self-licensing, motivation, opportunity cost

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Struggles with self-control pervade daily life (Hofmann, Baumeister, Förster, & Vohs, 2012). People can prevent temptations from derailing long-term goals by exerting self-control, which involves overriding undesirable emotions, thoughts, or behaviours (Baumeister, Vohs, & Tice, 2007). But self-control can apparently be depleted over time—that is, after using self-control, people enter into a state of ego depletion whereby further self-control attempts are prone to failure (Hagger, Wood, Stiff, & Chatzisarantis, 2010). However, the mechanisms underlying ego depletion remain debated (Inzlicht, Schmeichel, & Macrae, 2014; Kurzban, Duckworth, Kable, & Myers, 2013). The present study therefore sought to investigate possible processes that may lead to ego depletion.

Self-Control as a Limited Resource

Extensive evidence exists for the ego-depletion effect (Hagger et al., 2010). The prominent explanation is the strength model, which suggests that self-control draws on a limited resource (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister et al., 2007). Empirical tests of this model have typically used the dual-task paradigm whereby participants are asked to perform two sequential but unrelated self-control tasks (Hagger et al., 2010). For instance, compared with control participants who could freely express their emotions while watching an arousing video, those in the experimental condition who had to exert self-control to suppress their emotions tended to perform worse in a subsequent self-control task (Baumeister et al., 1998; Inzlicht & Gutsell, 2007). Such findings have led to the inference that using self-control consumes and depletes a limited resource, leaving one in a state of ego depletion whereby there is less self-control resources to draw on for subsequent tasks.

Although glucose has been proposed as the physical resource (Gailliot & Baumeister, 2007; Gailliot et al., 2007), many researchers have criticised the utility of the notion of resources. Some suggest that it is an evolutionarily and functionally implausible model (Beedie & Lane, 2012; Kurzban et al., 2013) and recent studies have failed to replicate the finding that using self-control lowers blood glucose levels (Molden et al., 2012). Moreover, the resource model cannot explain how reflecting on cherished values (Schmeichel & Vohs, 2009), believing that self-control is an unlimited resource (Job, Dweck, & Walton, 2010), or watching a comedy or receiving a surprise gift (Tice, Baumeister, Shmueli, & Muraven, 2007), can replenish the putative resource to counteract ego-depletion effects. Clearly, accumulating evidence has placed an increasing strain on the resource model of self-control and ego depletion.

Self-Control as a Motivational Phenomenon

Motivational Shifts

The focus has recently shifted away from resource models towards motivation-based accounts (Kurzban et al., 2013; Robinson, Schmeichel, & Inzlicht, 2010). Recent theorising and empirical evidence suggest that people are motivated to strike an optimal balance between cognitive labour and cognitive leisure (Cohen, McClure, & Yu, 2007; Inzlicht et al., 2014; Kool & Botvinick, 2014). Consequently, rather than depleting a resource, exerting self-control causes motivational and concomitant attentional and emotional shifts away from self-control and towards gratification (Inzlicht et al., 2014; Inzlicht & Schmeichel, 2012). For example, exerting self-control increases self-reported approach motivation and sensitivity to reward-relevant cues (Schmeichel, Harmon-Jones, & Harmon-Jones, 2010); it also impairs top-down executive control and increases activity in the orbitofrontal cortex, a brain region that encodes reward value (Wagner, Altman, Boswell, Kelley, & Heatherton, 2013). Moreover, the ego-depletion effect can be attenuated if depleted individuals are sufficiently motivated, such as by providing motivational incentives (Muraven & Slessareva, 2003) or inducing positive moods (Tice et al., 2007). Taken together, these findings suggest that ego depletion can be explained in terms of motivational shifts without recourse to the notion of resources.

Task Value and Opportunity Cost

Motivation is closely linked to the concept of task value, which plays a key role in determining performance on tasks that require cognitive control (Higgins, 2006; Kool & Botvinick, 2014). A new motivational model proposed by Kurzban et al. (2013) suggests that using cognitive control on any given task carries an opportunity cost, which is derived from comparing the benefits of engaging in the current task with the costs associated with not engaging in an alternative task. If an appealing alternative task of a higher value than the current task is available, it will be registered as an opportunity cost, which will then give rise to unpleasant sensations such as fatigue and boredom. As these feelings are postulated to serve as adaptive signals that motivate people to switch tasks, subsequent task performance may suffer because people become motivated to reallocate their executive processes.

Although there is currently little or no direct evidence indicating that Kurzban et al.'s (2013) model fares better than other models with ego-depletion effects, other lines of research have explored the effects of opportunity cost consideration. For example, consumer research indicates that people are less likely to buy a given product and more likely to buy cheaper alternatives when they have been reminded of alternative items they can buy (Frederick, Novemsky, Wang, Dhar, & Nowlis, 2009). In the educational context, students often have to commit to learning while forgoing tempting alternatives such as engaging in social activities or leisure (Grund & Fries, 2012). These alternatives can be seen as opportunity costs that may reduce motivation and impair self-regulation in learning (Fries, Dietz, & Schmid, 2008). For example, adolescents who worked on a learning task while waiting to perform a more appealing video-watching task were less motivated during learning and learned less than those who had watched the video first (Fries & Dietz, 2007). Thus, these findings suggest that the presence of appealing alternative options may influence decision making and impair self-control.

Self-Licensing: 'I Indulge Because I Deserve It'

A related motivational phenomenon is self-licensing: when people believe they have worked very hard or put in a lot of effort on a task, they subsequently become less motivated to control themselves and more likely to gratify their immediate desires (De Witt Huberts, Evers, & De Ridder, 2014; Shafir, Simonson, & Tversky, 1993; Xu & Schwartz, 2009). For example, after misleading participants into believing that they had put in more (vs. less) effort than necessary on a task (in reality all participants completed the same task), they tended to subsequently prefer chocolate cake over fruit salad as reward (Kivetz & Zheng, 2006) and consume more snacks (De Witt Huberts, Evers, & De Ridder, 2012). Thus, self-licensing effects are consistent with the notions of labour-leisure trade-off and motivational shifts after exerting cognitive control (Inzlicht et al., 2014). These findings suggest that ego-depletion effects may occur if people believe they have recently put in a lot of effort or exerted self-control.

The Present Research

We integrated the dual-task and self-licensing paradigms to test the resource model and motivation-based accounts of ego depletion. To manipulate resource depletion, we used the Stroop task—a standard depletion task that is frequently used in the dual-task paradigm (Hagger et al., 2010; Webb & Sheeran, 2003). Participants in depleting condition completed the incongruent Stroop task, whereas those in the non-depleting condition completed a less cognitively demanding version of the task. Based on the resource model (Baumeister et al., 2007), completing the depleting (vs. non-depleting) Stroop task should lead to worse performance on a subsequent self-control task.

However, ego depletion may instead be due to motivational factors. As suggested by motivation-based accounts (De Witt Huberts et al., 2014; Kurzban et al., 2013) but not the resource model, the presence of alternative initial tasks of varying degrees of appeal or difficulty may affect performance on a subsequent self-control task. To test this, we presented the Stroop task alongside an alternative task that was either easier or more difficult—this manipulated the perceived difficulty of the Stroop task. Thus, within each Stroop condition (non-depleting or depleting), participants were misled into believing they had completed either an easy or difficult task.

We used a 2 (Stroop condition: non-depleting, depleting) x 2 (perceived-difficulty condition: easy, difficult) between-subjects design. First, we predicted that participants in the depleting (vs. non-depleting) condition would perform worse on a second self-control task. However, it must be noted that this effect, which is the central prediction of the resource model (Baumeister et al., 2007), has not always been replicated (Dang, Dewitte, Mao, Xiao, & Shi, 2013; Dewitte, Bruyneel, & Geyskens, 2009). Second, given that the presence of an appealing alternative option can trigger opportunity cost consideration (Kurzban et al., 2013) and lead to self-licensing (De Witt Huberts et al., 2014), we predicted that those who believed they had completed a difficult (vs. easy) initial task would also perform worse on the second task. Finally, existing theoretical and empirical evidence (Kurzban et al., 2013) did not suggest an interaction between Stroop and perceived-difficulty conditions.

To investigate the motivational mechanisms underlying ego depletion, we tested whether cognitive exertion may lead to increased approach motivation or a desire for gratification (Inzlicht et al., 2014). We attempted to replicate and extend Schmeichel et al.'s (2010) findings by measuring self-reported approach motivation immediately after participants completed the initial task. Consistent with their findings, we predicted that participants in the depleting (vs. non-depleting) condition would report higher levels of approach motivation. As having the belief that one has worked hard can serve as a justification to license subsequent gratification (De Witt Huberts et al., 2014), we hypothesised that participants in the difficult (vs. easy) condition would also report higher levels of approach motivation. Again, existing evidence did not suggest an interaction between Stroop and perceived-difficulty conditions.

To investigate other potential mechanisms underlying ego depletion, we also measured task motivation and mood because changes in these two variables have been proposed to mediate the effect of ego depletion on self-control task performance (Inzlicht et al., 2014; Kurzban et al., 2013; Robinson et al., 2010).

Method

Participants and Design

Ninety-one non-psychology students were recruited by email from the university and entered a £25 prize draw for their participation. We provided a cover story by telling participants that the study was an investigation of colour perception and problem solving that would last approximately 30 minutes. This was to ensure that participants remained unaware that we were investigating self-control because such knowledge would invalidate their performance and data. They were randomly assigned to one of four conditions in a 2 (Stroop condition: non-depleting, depleting) x 2 (perceived-difficulty condition: easy, difficult) between-subjects design. The main dependent variables were persistence in the second self-control task (anagram task) and self-reported approach motivation. Thirteen participants were excluded from analyses because funnel debriefing revealed that two misunderstood task instructions, five saw through the perceived-difficulty manipulation, and six realised we were investigating self-control, leaving 78 participants (58% female; $M = 21.24$, $SD = 4.45$; age range: 17–42).

Materials

Depletion manipulation. The Stroop task was used as the self-control depletion task because it represents a classic task that demands cognitive control (Shenhav, Botvinick, & Cohen, 2013) and has been successfully used as a depleting task in many self-control studies (Hagger et al., 2010). Participants were assigned to work on either the non-depleting or depleting Stroop task for about 6 minutes. The task consisted of 10 practice trials and 168 actual trials. In the non-depleting condition, strings of meaningless letters in different colours (e.g., MQNV in red font) were shown one at a time on a computer display. Participants had to indicate as quickly and accurately as possible the colour of the letters by pressing the corresponding key on the keyboard. In the depleting condition, participants saw colour words that mismatched their semantic meaning (e.g., RED in yellow font). They had to indicate the colour of each word unless the word was ‘BLUE’, in which case they had to always respond with the blue key regardless of the colour of the word. The depleting (vs. non-depleting) task should deplete more self-control resources because it required participants to override their natural tendency to read the words. For each participant, we calculated their Stroop inverse efficiency score by dividing their mean reaction time by the proportion of correct responses (Bruyer & Brysbaert, 2011); higher scores indicated worse performance in the task.

Perceived-difficulty manipulation. Within each Stroop condition (non-depleting or depleting), participants were misled into believing that they had completed an easy or difficult initial task. For those in the easy condition, the Stroop task appeared to be an easy task because it was presented alongside a speech task that required them to deliver a speech that would be recorded and judged by two independent evaluators. For those in the difficult condition, the Stroop task appeared to be a difficult task because it was presented alongside a comedy task that only required them to watch a 60-second comedy and answer a few questions subsequently. All participants were asked to complete the Stroop task; the speech and comedy tasks served only to manipulate the relative perceived difficulty of the Stroop task.

Anagram task. The main dependent measure was a computerised anagram task that consisted of 80 five-letter solvable anagrams. Following Vohs et al. (2008), participants were instructed to work on the list of anagrams until they solved them all, wanted to stop, or decided to give up. They could stop any time by clicking a button located at the bottom of the page. The computer timed their efforts directed at this task as a measure of persistence.

Approach motivation. To assess whether the manipulations had affected approach motivation, we followed Schmeichel et al. (2010) by using the behavioural activation system scale (Carver & White, 1994). This scale consists of 13 items (e.g., ‘When I see an opportunity for something I like, I get excited right away.’) and responses ranged from *very false for me* (1) to *very true for me* (4). Higher scores indicated stronger approach motivation (α = .81).

Intrinsic task motivation. To investigate whether task motivation mediated the effects of our results, we used the Intrinsic Motivation Inventory (e.g., Ryan, 1982) to measure intrinsic motivation for both the Stroop and anagram tasks. Following previous research (e.g., Muraven et al., 2008), we used only the interest/enjoyment subscale of the inventory because it consists of seven items that most closely represent the experience of intrinsic task motivation (e.g., ‘I thought this activity was quite enjoyable’). Responses ranged from *not at all true* (1) to *very* *true* (7). The intrinsic motivation scales for the Stroop (α = .87) and anagram (α = .89) tasks were reliable.

Mood. We also tested whether our results were due to changes in mood by having participants complete the short-form 10-item Positive and Negative Affect Schedule (PANAS; Thompson, 2007) after completing the Stroop task. Five item assessed positive moods (alert, inspired, determined, attentive, active) and five assessed negative moods (upset, hostile, ashamed, nervous, afraid). Participants rated the degree to which they felt each mood in the current moment on a 5-point scale ranging from *not at all* (1) to *very much* (5). Both the positive (α = .78) and negative (α = .82) subscales were reliable.

Procedure

Participants were tested individually. Standardised instructions were used throughout the study and all tasks and questionnaires were completed on a computer. First, participants were given two minutes to read the printed instructions for two tasks: the Stroop (non-depleting or depleting) task and an alternative task (speech or comedy). The instructions stated that participants would be randomly assigned to work on either of the tasks. The experimenter returned two minutes later and informed the participant that they had been assigned the Stroop task because the alternative task had already been assigned to another participant in another room. After completing the Stroop task, participants completed the self-report measures of intrinsic motivation, approach motivation, and the PANAS. They then proceeded to the anagram task. After which, they completed the self-report measure of intrinsic motivation for the anagram task. Last, they were carefully probed for suspicion with a funnel debriefing procedure and thanked for their participation.

Results

Two participants were excluded from all subsequent analyses because their persistence scores (60.05, 76.02) were greater than three standard deviations from the mean of their respective conditions, leaving a final sample of 76 participants. Variables were transformed when necessary; but for ease of interpretation, we presented the untransformed scores for all variables (see Table 1). Unless stated otherwise, a 2 (Stroop condition: non-depleting, depleting) x 2 (perceived-difficulty condition: easy, difficult) ANOVA was used.

Table 1

Means and Standard Errors for Study Variables By Stroop and Perceived-Difficulty Conditions

	Easy				Difficult			
	Non-Depleting Stroop (n = 20)		Depleting Stroop (n = 21)		Non-Depleting Stroop (n = 18)		Depleting Stroop (n = 17)	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Stroop Task								
IES	675.35	28.40	1148.04	58.92	713.94	42.80	1223.96	74.30
Intrinsic Motivation	4.19	0.26	4.74	0.25	4.76	0.24	4.58	0.26
Approach Motivation	3.25	0.09	3.00	0.10	3.17	0.08	3.13	0.11
Mood								
Positive	3.00	0.21	3.13	0.19	3.53	0.15	2.93	0.20
Negative	1.61	0.17	1.62	0.17	1.62	0.18	1.52	0.18
Anagram Task								
Persistence (min)	23.30	2.28	20.54	1.95	14.66	1.01	16.50	2.12
Intrinsic Motivation	4.47	0.32	3.52	0.27	4.25	0.26	3.66	0.25

Note. $N = 76$. IES: Inverse Efficiency Score. Means with different subscripts differ at $p < .05$.

Manipulation Check

Stroop performance. Within each participant, reaction times greater or less than three SDs away from that participant's individual mean were removed (1.44% of the trials) before computing the Stroop inverse efficiency score. To correct for violations of homogeneity of variance, we log-transformed the variable. Participants in the depleting ($M = 1182.00$, $SE = 46.30$) condition scored significantly higher than those in the non-depleting ($M = 693.63$, $SE = 25.03$) condition, $F(1, 72) = 104.59$, $p < .001$, $r = .77$, indicating that those in the depleting condition performed worse in the Stroop task. Neither the perceived-difficulty condition nor the Stroop x perceived-difficulty interaction was significant, $F\text{s} < 1.02$, $p\text{s} > .316$, $r\text{s} < .12$. Taken together, these findings suggest that the depleting Stroop task should have been objectively more cognitively demanding than the non-depleting task. Crucially, participants in the easy and difficult conditions performed similarly, suggesting that the perceived-difficulty manipulation had not affected actual self-control demand and exertion.

Did Persistence and Approach Motivation Differ by Condition?

Anagram persistence. To correct for violations of homogeneity of variance, we square-root transformed the persistence variable. Only the main effect of perceived-difficulty condition was significant, $F(1, 72) = 9.28$, $p = .003$, $r = .34$. Participants who believed they had completed an easy initial task (*M* = 21.89, *SE* = 1.49) persisted longer on the anagram task than those who believed they had completed a difficult initial task (*M* = 15.55, *SE* = 1.15). There was a non-significant main effect of Stroop condition, $F(1, 72) = 0.17$, $p = .686$, $r = .04$. The Stroop x perceived-difficulty interaction was also non-significant, $F(1, 72) = 0.81$, $p = .370$, $r = .11$. Thus, contrary to the resource model's predictions, completing the non-depleting or depleting Stroop task did not affect the extent to which participants persisted on the anagram task.

Approach motivation. There was a non-significant main effect of Stroop condition, $F(1, 72) = 2.25$, $p = .138$, $r = .17$ and a non-significant main effect of perceived-difficulty condition on approach motivation, $F(1, 72) = 0.04$, $p = .851$, $r = .02$. The interaction was also non-significant, $F(1, 72) = 1.28$, $p = .262$, $r = .13$. Thus, contrary to the findings of Schmeichel et al. (2010, Study 1) who used the same measure of approach motivation, our Stroop and perceived-difficulty manipulations did not lead to differences in self-reported approach motivation across the conditions.

Did Intrinsic Motivation and Mood Differ by Condition?

Intrinsic motivation. Both the main effects of Stroop and perceived-difficulty conditions on Stroop intrinsic motivation were non-significant, Fs < 0.66, ps $> .418$, rs $< .10$. The interaction was also non-significant, $F(1, 72) = 2.10$, $p = .151$, $r = .17$. Therefore, intrinsic motivation for the Stroop task was similar across the conditions. For anagram intrinsic motivation, there was a significant main effect of Stroop condition, $F(1, 72) = 7.77$, $p = .007$, $r = .31$, suggesting that completing the depleting (vs. non-depleting) Stroop task led to lower intrinsic motivation for the anagram task. Neither the main effect of perceived-difficulty condition nor the interaction was significant, Fs < 0.40, ps $> .531$, rs $< .07$. These findings suggest that the perceived-difficulty manipulation did not lead to differences in anagram intrinsic motivation.

Mood. As in many self-control studies, we assessed whether our manipulations influenced participants' moods. For positive moods, the main effects of Stroop and perceived-difficulty conditions were non-significant, Fs < 1.52, ps $> .22$, rs $< .14$. The interaction was also non-significant, $F(1, 72) = 3.73$, $p = .058$, $r = .22$. The negative moods variable was positively skewed and we used a log transformation to normalise the distribution. Neither of the main effects nor the interaction was significant, Fs < 0.21, ps $> .649$, rs $< .05$. Thus, our manipulations had not led to differences in positive or negative moods across the conditions.

Mediation. We tested whether the effects of our manipulations on anagram persistence were mediated by changes in intrinsic task motivation and mood. Perceived-difficulty condition (coded so that easy condition = 0 and difficult condition = 1) predicted anagram persistence, $b = -6.33$, $p = .002$. However, perceived-difficulty condition was unrelated to all of the potential mediators: Stroop intrinsic motivation, $b = 0.20$, $p = .430$, anagram intrinsic motivation, $b = -0.02$, $p = .937$, positive moods, $b = 0.17$, $p = .380$, and negative moods, $b = -0.04$, $p = .804$. Thus, neither changes in intrinsic task motivation nor mood mediated the effects of our manipulations on anagram persistence.

Discussion

While recent theorising suggests that ego depletion is a motivational phenomenon rather than a matter of resource depletion (Inzlicht et al., 2014; Kurzban et al., 2013), existing empirical evidence cannot distinguish between these two accounts (Hagger et al., 2010). The present study attempted to test these explanations.

We found that completing the depleting (vs. non-depleting) Stroop task did not impair performance on the second self-control task. Thus, contrary to our prediction, which is also the main prediction of the resource model (Baumeister et al., 2007), working on a task that objectively requires more self-control or cognitive exertion might not always lead to ego depletion. This is somewhat unsurprising given recent scepticism regarding the notion of self-control resources and its depletion (Kurzban et al., 2013) and failures to replicate ego-depletion effects (e.g., Dang et al., 2013; Molden et al., 2012). But what is more interesting was the finding that participants who believed they had completed a difficult (vs. easy) initial task performed worse on the second self-control task. While this finding is hard for the resource model to accommodate, it is consistent with the predictions of the various motivational models, which suggest that simply getting people to believe they have worked harder than necessary can lead to ego-depletion effects (De Witt Huberts et al., 2014; Inzlicht et al., 2014). Overall, this pattern of results is more readily accommodated by motivation-based accounts than by the resource model.

However, contrary to predictions and existing evidence (Inzlicht et al., 2014; Schmeichel et al., 2010), none of our manipulations had any effect on self-reported approach motivation. As we are unaware of any accepted state measure of approach motivation, we used a trait measure (behavioural activation system scale; Carver & White, 1994) that might not have been sufficiently sensitive to detect the effects of our manipulations. Such an interpretation would be consistent with findings from a recent neuroimaging study: ego-depleted dieters showed enhanced neural responses in a brain region that encodes reward value when they saw food-related reward cues, suggesting that ego depletion increases approach motivation (Wagner et al., 2013). Thus, our lack of significant effects may reflect the limitations of our trait measure rather than challenge the notion that cognitive exertion can lead to motivational shifts towards gratification (Inzlicht et al., 2014).

We found that changes in intrinsic task motivation and mood did not mediate the effects of our manipulations on self-control performance on the second task. Our findings may be consistent with many previous studies which found that neither motivation nor mood mediated the effects (e.g., Bruyneel & Dewitte, 2012; DeBono & Muraven, 2013). But such findings appear to be at odds with the opportunity cost model's suggestion that ego depletion should be accompanied by unpleasant sensations that serve to motivate reallocation of executive processes (Kurzban et al., 2013). It is worth noting that we followed previous research by using the PANAS (Hagger et al., 2010), which measures negative affect such as ashamed, nervous, and upset; but these unpleasant sensations might not have been central to the opportunity cost model. For example, Job et al. (2010) showed that subjective exhaustion or fatigue—an important sensation according to the opportunity cost model (Kurzban et al., 2013)—mediated the relationship between depletion and subsequent self-control performance. Thus, our findings do not necessarily challenge motivation-based accounts because we might not have identified and measured the most relevant mediators.

While our results may highlight the role of motivational processes in contributing to ego depletion, the resource model remains a possible explanation for our findings. Although unlikely, it is plausible that believing that one has completed a difficult rather than easy task might have led to resource depletion. But as the putative resource has yet to be identified and no objective measure of resource depletion currently exists (Hagger et al., 2010; Inzlicht et al., 2014), it remains a methodological challenge to empirically test any claims made by the resource model. Moreover, Baumeister and Vohs (2007) extended their resource model, proposing that resources can be conserved or overused under specific circumstances. According to critics of resource models (Kurzban et al., 2013; Navon, 1984), this additional postulate allows Baumeister and colleagues' (1998, 2007) resource model of ego depletion to accommodate almost any pattern of findings, rendering the theory unfalsifiable. Thus, motivation-based accounts are preferable to the resource model, especially since the former tends to provide hypotheses that not only are more precise and falsifiable but also would not otherwise be anticipated by the resource model (Inzlicht & Schmeichel, 2012).

Although our results suggest that ego depletion may be better construed as a motivational phenomenon rather than depletion of resources, several limitations should be noted. Our design precluded a differentiation of the various motivational explanations: we could not establish whether motivational shifts, opportunity cost consideration, self-licensing, or a combination of these factors led to ego depletion. More empirical work is needed to investigate whether the various motivational models can be integrated or distinguished. For example, Inzlicht and colleagues (2013, 2014) attempted to reconcile these models, suggesting that their model explains *how* cognitive exertion leads to ego depletion while the opportunity cost model explains *why* ego depletion exists. By resolving these empirical and conceptual issues, researchers can avoid falling into the trap of merely replacing the perhaps unnecessary notion of *resources* (Navon, 1984) with *motivation*—a potentially even more unwieldy concept (see Berridge, 2004 for a discussion of motivation).

Another potential limitation is the nature of the depleting task. Although the depleting (incongruent) Stroop task is frequently used in self-control studies as a depleting task (Hagger et al., 2010), recent findings suggest that this task may be less effortful and require less cognitive control than previously thought. For example, participants might be able to develop strategies to cope with and adapt to the demands of the Stroop task (Bugg, 2014; Dang et al., 2013). Thus, the depleting Stroop task might not have required more self-control than the non-depleting task. This might explain why participants who completed the depleting (vs. non-depleting) task did not show signs of ego depletion, as measured by performance in the subsequent task.

Our findings might also have been limited by the characteristics of the dependent measure and experimental context. In the present study, participants completed the Stroop task and post-task questionnaires in about 10 minutes. They then, on average, persisted on the anagram task for about 19 minutes. It has been suggested that experimental sessions can be construed as a relationship whereby participants exchange their time and effort for some form of compensation (Kurzban et al., 2013; Orne, 1962). Therefore, our participants, who had been informed beforehand that the study would last approximately 30 minutes, might have felt motivated or obliged to expend approximately that much time and effort on the experiment. Thus, even though we did find significant effects, it stands to reason that effect sizes would be greater if we had used a measure of self-control that did not involve persistence; future studies will be necessary to test this possibility.

Whatever the empirical and theoretical challenges, it is encouraging to see specific motivation-based accounts of ego depletion now emerging and we offer five suggestions for future research. First, better tests of whether cognitive exertion causes motivational shifts towards gratification can use behavioural measures of approach motivation, which are more sensitive than self-report measures (Harmon-Jones, Gable, & Price, 2013; Schmeichel et al., 2010). Second, future studies can parametrically vary the appeal of alternative tasks relative to the focal task. The opportunity cost model (but not the resource model) predicts that such manipulations should lead to systematic differences in task performance (Kurzban et al., 2013). Third, Kurzban et al. (2013, p. 673) posited that 'phenomenology drives behaviour.' Thus, to test their model, future studies should investigate not only whether cognitive exertion gives rise to relevant unpleasant sensations but also whether inducing these sensations will lead to ego-depletion effects. This leads to the fourth suggestion: future research investigating the processes underlying ego depletion should seek to identify potential mediators and test for mediation by experimentally manipulating these mediators (Inzlicht & Schmeichel, 2012). Finally, future studies should use different depletion manipulations and outcome measures to investigate the generalisability of our findings.

In conclusion, this study contributed to the ongoing theoretical debate concerning the underlying mechanisms of ego depletion. Our findings suggest that ego depletion may be better explained by motivational factors than by resource depletion. That is, people often fail at self-control not because they are depleted of self-control resources but because they are motivated to not exert self-control. Our findings also have practical implications. Interventions that focus on sustaining or altering motivations can be developed to help people cope with self-control struggles that pervade their everyday lives. As suggested by Inzlicht and colleagues (2012, 2014), a central challenge of future research, therefore, will be to examine the precise motivational mechanics underlying self-control and its depletion.

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