Psychological Bulletin
2010, Vol. 136, No. 4, 495–525

0033-2909/10/$12.00 DOI: 10.1037/a0019486

Ego Depletion and the Strength Model of Self-Control: A Meta-Analysis

Martin S. Hagger, Chantelle Wood, and Chris Stiff
University of Nottingham

Nikos L. D. Chatzisarantis
National Institute of Education, Singapore

According to the strength model, self-control is a finite resource that determines capacity for effortful control over dominant responses and, once expended, leads to impaired self-control task performance, known as *ego depletion*. A meta-analysis of 83 studies tested the effect of ego depletion on task performance and related outcomes, alternative explanations and moderators of the effect, and additional strength model hypotheses. Results revealed a significant effect of ego depletion on self-control task performance. Significant effect sizes were found for ego depletion on effort, perceived difficulty, negative affect, subjective fatigue, and blood glucose levels. Small, nonsignificant effects were found for positive affect and self-efficacy. Moderator analyses indicated minimal variation in the effect across sphere of depleting and dependent task, frequently used depleting and dependent tasks, presentation of tasks as single or separate experiments, type of dependent measure and control condition task, and source laboratory. The effect size was moderated by depleting task duration, task presentation by the same or different experimenters, intertask interim period, dependent task complexity, and use of dependent tasks in the choice and volition and cognitive spheres. Motivational incentives, training on self-control tasks, and glucose supplementation promoted better self-control in ego-depleted samples. Expecting further acts of self-control exacerbated the effect. Findings provide preliminary support for the ego-depletion effect and strength model hypotheses. Support for motivation and fatigue as alternative explanations for ego depletion indicate a need to integrate the strength model with other theories. Findings provide impetus for future investigation testing additional hypotheses and mechanisms of the ego-depletion effect.

Keywords: self-control strength, self-regulation, limited resource, dual-task paradigm, research synthesis

Supplemental materials: http://dx.doi.org/10.1037/a0019486.supp

In everyday life people show a remarkable capacity to regulate the self and overcome the impulses and drives that tempt us to overeat, drink too much alcohol, take harmful recreational drugs, engage in violent actions when provoked, say hurtful things to others, spend money beyond their means, engage in inappropriate sexual activity, or procrastinate when they should be working (Steel, 2007; Tice & Bratslavsky, 2000). This ability to attain deliberative control over impulses (Ainslie, 1975; Eisenberg et al., 2003; Fujita & Han, 2009) and abstain from gratifying immediate needs and desires (Metcalfe & Mischel, 1999; Mischel, Shoda, & Rodrieguez, 1989) is extremely adaptive and enables people to engage in goal-directed behavior to bring about long-term desirable outcomes (Baumeister, 2005; Fishbach & Labroo, 2007; Logue, 1988). If people were unable to regulate their behavior, life would become a series of unconstrained impulsive actions to service immediate urges, desires, and emotions. Goal-directed behavior and the achievement of long-term outcomes would become impossible, as people would not be able to engage in the disciplined, focused effort required (Loewenstein, 1996).

Despite the human capacity to regulate the self, many behavioral and social problems stem from persistent lapses of self-control. Problems such as obesity, drug abuse, violent crime, inability to manage finances (including personal debt and gambling problems), unplanned pregnancy, eating disorders, sexually transmitted disease, and some chronic diseases (e.g., cancer and heart disease) have their roots, directly or indirectly, in self-regulation failure (Baumeister, Heatherton, & Tice, 1994; Muraven & Baumeister, 2000; Wills & Stoolmiller, 2002). Analogously, successful regulation of the self contributes to many adaptive outcomes in society, such as success at school, at college, and in the workplace; cohesive personal relationships; superior physical and mental health; better ability to cope with problems; and reduced susceptibility to social ills like drug abuse and criminality (Gailliot & Baumeister, 2007a; Hammer, 2005; Levy, 2006; Tangney, Baumeister, & Boone, 2004). The high importance of self-regulation to such behaviors and concomitant outcomes has meant that it has become the focus of a considerable body of research in social psychology.

Martin S. Hagger, Chantelle Wood, and Chris Stiff, School of Psychology, University of Nottingham, Nottingham, Nottinghamshire, United Kingdom; Nikos L. D. Chatzisarantis, National Institute of Education, Nanyang Technical University, Singapore.

Chantelle Wood is now at the Institute of Psychological Sciences, University of Leeds, Leeds, West Yorkshire, United Kingdom. Chris Stiff is now at the School of Psychology, Keele University, Keele, Staffordshire, United Kingdom.

The research was supported in part by Leverhulme Trust Grant F/00568/R, awarded to Nikos L. D. Chatzisarantis and Martin S. Hagger. We thank James M. Tyler and Rex A. Wright for their helpful comments on an earlier draft of this paper.

Correspondence concerning this article should be addressed to Martin S. Hagger, Personality, Social Psychology, and Health Research Group, School of Psychology, University of Nottingham, University Park, Nottingham, Nottinghamshire NG7 2RD, United Kingdom. E-mail: martin.hagger@nottingham.ac.uk

Research into self-regulation and failure of self-control has frequently adopted cognitive models in which self-regulation is viewed as a function of beliefs, judgments, expectations, attitudes, and intentions (Ajzen, 1985; Bagozzi, 1992; Koestner, Bernieri, & Zuckerman, 1992; Sansone & Smith, 2000). In contrast, capacity-based approaches propose that self-control is a limited commodity that restricts self-regulatory capability (Baumeister & Heatherton, 1996; Fishbach, Friedman, & Kruglanski, 2003; Metcalfe & Mischel, 1999; Mischel et al., 1989). Inspired by this approach, Baumeister and colleagues (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister & Heatherton, 1996; Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000; Vohs & Heatherton, 2000) developed the *strength model* of self-control.[1] A major tenet of the model is that engaging in acts of self-control draws from a limited "reservoir" of self-control that, when depleted, results in reduced capacity for further self-regulation. In the model, self-control is viewed as analogous to a muscle. Just as a muscle requires strength and energy to exert force over a period of time, acts that have high self-control demands also require strength and energy to perform. Similarly, as muscles become fatigued after a period of sustained exertion and have reduced capacity to exert further force, self-control can also become depleted when demands are made of self-control resources over a period of time. Baumeister and colleagues termed the state of diminished self-control "strength" *ego depletion*.

An increasing body of research has supported the short-term self-regulatory deficits predicted by the strength model (Baumeister, Gailliot, DeWall, & Oaten, 2006; Muraven & Baumeister, 2000). Self-control resource depletion has also been shown to coincide with increased subjective and physiological effort, fatigue, and task difficulty. The model has been further extended to include hypotheses based on the strength or energy metaphor. For example, anticipating future self-control demands results in people conserving energy for future effort, just as an athlete spares his or her muscles in anticipation of forthcoming demands (Muraven, Shmueli, & Burkley, 2006). Regular training on tasks requiring self-regulation can attenuate the ego-depletion effect; just as training a muscle increases its endurance and strength (Gailliot, Plant, Butz, & Baumeister, 2007; Muraven, Baumeister, & Tice, 1999; Oaten & Cheng, 2006a, 2006b, 2007). Finally, rest and recuperation can regenerate self-control, just as a muscle's strength returns after a period of rest (Muraven & Baumeister, 2000; Tyler & Burns, 2008).

Given the burgeoning literature in the field of self-control and the strength model, a meta-analytic synthesis of the ego-depletion effect is important and timely. This article makes a unique contribution to knowledge on self-control by testing the size and consistency of the ego-depletion effect in the extant literature. It resolves whether inconsistencies in the size of the effect are due to methodological artifacts or whether there is substantial variation in the effect across studies due to the existence of extraneous moderating variables. The analysis also tests whether the self-control deficits observed in ego-depletion experiments can be accounted for by alternative explanations—such as skill, fatigue, motivation, self-efficacy, and negative affect—and whether these are consistent with, or contradict, the strength model. Another aim was to identify potential moderators of the effect, such as the defining characteristics of self-control tasks and experimental design. The effect of ego depletion on other variables that have been suggested as indicators of depletion (e.g., effort, perceived difficulty, subjective fatigue, blood glucose levels) is also examined. Finally, the conservation, training, and recovery hypotheses based on the strength model are tested. The theoretical background to each of these issues is discussed next.

Self-Control and the Strength Model

The strength model offers an explanation for self-control that transcends cognitive and associative-learning models (Baumeister et al., 1998). It predicts that acts of self-control draw from a common, global resource. The resource is limited and vulnerable to becoming depleted over time, just as a muscle becomes tired after a period of exertion. As a consequence, after people have engaged in an act of self-control, their capacity to exercise further self-control becomes exhausted, leading to decreased performance on subsequent acts of self-control. According to the model, once a person's self-control reserves have been depleted, the resulting state of ego depletion can be counteracted by replenishing the resource through rest or relaxation (Tyler & Burns, 2008) or by taking on fuel (Gailliot, Baumeister, et al., 2007).

Empirical tests of the ego-depletion effect have typically adopted an experimental procedure using two unrelated self-control tasks, known as the *dual-task paradigm* (Baumeister et al., 1998; Finkel et al., 2006; Muraven, Tice, & Baumeister, 1998). Participants assigned to an experimental ego-depletion group are required to engage in two consecutive tasks requiring self-control. Control participants are also required to engage in two consecutive tasks, but only the second task requires self-control. The strength model predicts that experimental-group participants' performance on the second self-control task will be impaired relative to that of control-group participants. This is because the finite self-control resources of the experimental participants will be diminished after the initial self-control task, leaving little to draw on for the second task (Baumeister et al., 2007).

Adopting this paradigm, Baumeister and coworkers (Baumeister et al., 1998; Muraven et al., 1998) provided initial support for the ego-depletion effect. For example, one study required those in the experimental group to suppress their emotions when watching an evocative video; controls were informed they could freely express their emotions. Participants were then required to hold a spring-loaded handgrip to exhaustion. Compared with the control group, participants who suppressed their emotions had signifi-

[1] Self-control is defined as the capacity of the individual to alter, modify, change, or override his or her impulses, desires, and habitual responses (Baumeister & Heatherton, 1996). Quite literally, it is the ability of the self to exert control over the self. Other terms often considered synonymous with self-control include *willpower, self-discipline,* and *self-regulation* (Duckworth & Seligman, 2005; Henden, 2008; Mischel, 1996). Self-control and self-regulation, in particular, are often used interchangeably in the literature (Baumeister et al., 2007; Hofmann et al., 2007). Self-control can be viewed as a specific case of self-regulation in which the person exerts deliberate and conscious effort to control the self, and self-regulation is a global term that also encompasses reflexive and nonconscious regulatory processes such as homeostasis (Baumeister, Vohs, & Tice, 2007). In this article we define self-control as the effortful capacity of the individual to regulate his or her emotions, thoughts, impulses, or other well-learned or automatic behavioral responses (Vohs, 2006).

cantly impaired performance on the handgrip task (Muraven et al., 1998). In another study, participants assigned to the experimental group were required to eat radishes and resist the temptation of appetizing chocolates, but controls were asked to eat the chocolates and leave the radishes. The experimental participants exhibited significantly lower persistence on a subsequent unsolvable geometric puzzle task (Baumeister et al., 1998). According to the strength model, suppressing emotions or resisting the tempting food required the overriding of a habitual or dominant response and led to the depletion of self-control resources. This resulted in impaired performance on subsequent tasks due to the reduced availability of self-control resources. The effect has been replicated on numerous occasions by Baumeister and colleagues (for reviews, see Baumeister & Vohs, 2007; Baumeister et al., 2007) as well as researchers in other laboratories (e.g., Martijn et al., 2007; Tyler, 2008; Wright, Martin, & Bland, 2003), and it has been shown to be relatively consistent across different spheres or domains of depletion. The findings provide support for a global self-control resource, because the transfer of the effect across spheres suggests that ego depletion is not an artifact of a particular task or domain.

However, a minority of studies adopting these methods have reported nonsignificant ego-depletion effects (e.g., Stillman, Tice, Fincham, & Lambert, 2009; Wright et al., 2007; Wright, Stewart, & Barnett, 2008). For example, Stillman et al. (2009) found that participants assigned to an ego-depletion group that required them to engage in a thought suppression task did not differ in their persistence on a word production task relative to controls who were not required to suppress their thoughts. Wright et al. (2007) used a difficult counting task to deplete self-control resources and found that performance on a subsequent mental arithmetic task did not differ from that of a control group that performed an easy initial counting task. These findings suggest that support for the ego-depletion effect is not unequivocal, and there are variations across the literature. Furthermore, the inconsistencies may be due to the presence of moderating factors, such as the features of the tasks used. The present meta-analytic synthesis of the findings of ego-depletion studies therefore makes an important contribution to the literature by estimating whether the effect is present in the population, resolving inconsistencies in the literature, and testing the degree of heterogeneity associated with the effect.

Alternative Explanations

Other explanations have been put forward to explain the self-regulatory failures observed in ego-depletion experiments. The aim in this section is to review these alternative explanations, compare their tenets with those of the strength model, and identify whether they are consistent with, compete with, or complement its predictions.

Skill

Self-control capacity can be conceptualized as a skill that is developed over time and that enables people to actively invest the required effortful action to bring about future goals or outcomes (Carver & Scheier, 1998; Wills & Dishion, 2004). Baumeister and coworkers (Baumeister et al., 1998; Muraven et al., 1998) proposed that a skill model would predict relatively little change in performance across the first and second tasks in dual-task paradigm experiments, as people would merely apply the well-learned skill to each task they encounter. According to this view, self-control capacity is an acquired, relatively stable skill that, once learned, would result in a relatively consistent performance on consecutive self-control tasks. The consistent decrement in self-control task performance observed in ego-depletion experiments led Baumeister et al. (1998) to reject skill as a plausible explanation.

However, Baumeister and colleagues recognized that people may experience learning (Baumeister et al., 1998) or "warm-up" (Muraven et al., 1998) periods in performance on self-control tasks, particularly novel ones, suggesting that there may be circumstances in which performance improves with time. Indeed, research in the area of skill acquisition and motor learning suggests that people's learning of skills over time is both gradual and transferable (J. R. Anderson, 1982; Rosenbaum, Carlson, & Gilmore, 2001). Therefore, in the early stages of the development of self-control skills performance may increase but, assuming the transferability of the self-control "skill," this would eventually stabilize and be applicable across different spheres or domains. In addition, skill improvement is a relatively slow, long-term process, but ego depletion has generally been tested as a relatively short-term deficit in studies adopting the dual-task paradigm (Vohs et al., 2008). As a result, short-term variations in self-control capacity may not be influenced by the gradual changes in self-control capacity due to the learning of self-control "skills." This is supported by observed decrements in postdepletion second-task performance in dual-task paradigm experiments rather than no change or improvement. The overall weight of evidence seems to lend support to a limited resource model of short-term self-control capacity rather than a skill-based model.

Although much of the research on the strength model has focused on short-term resource depletion (Vohs et al., 2008), there is evidence that chronic experience or practice on self-control tasks results in improvements in self-regulatory capacity. Individuals practiced on self-control tasks appear to be less vulnerable to ego depletion (Hui et al., 2009; Muraven et al., 1999). This is consistent with the strength model in that exercise increases self-control strength, allowing for a deeper pool of resources to be available for subsequent performance on self-control tasks. Alternatively, a skill model implies that the increased practice results in increases in the efficiency with which self-control resources are used. This is not inconsistent with the strength model, as a limited self-control resource is implicated in the process, but it provides an alternative to the "extended pool" explanation. A skill model may therefore have utility in explaining long-term improvements in self-control capacity. An aim in the present analysis was to examine the effects of self-control practice as a means to promote self-regulatory capacity. The issue of training and ego depletion is discussed further in the section on extensions to the strength model.

Fatigue

Fatigue is likely to be implicated in the ego-depletion effect. Theory suggests that people experience subjective fatigue when mental resources are taxed (Cameron, 1973). Furthermore, self-control resource depletion appears to coincide with subjectively felt and physiological indicators of fatigue. Decrements in subjec-

tive fatigue have been shown in people engaging in depleting tasks in ego-depletion experiments (e.g., Finkel et al., 2006; Friese, Hofmann, & Wanke, 2008; Stewart, Wright, Hui, & Simmons, 2009). In addition, subjective fatigue evoked by engaging in cognitively demanding tasks leads to elevated physiological indicators of generalized fatigue and reduced performance on subsequent tasks (Segerstrom & Nes, 2007; Wright et al., 2007, 2008). Such effects suggest that fatigue may not be a mere indicator of ego depletion but a mediator of the effects of self-regulatory resource depletion on subsequent task performance (Muraven et al., 1998). For example, the exertion of self-control requires effort, which can lead to fatigue and, in turn, decreased capacity to exert self-control in the future. Fatigue may also motivate people to conserve their self-control resources when depleted (Muraven, Shmueli, & Burkley, 2006). However, few studies have examined subjective fatigue as a mediator of ego depletion. We aimed to examine the average effect of ego depletion on fatigue as well as other subjective indices of self-regulatory demand, such as effort and perceived difficulty, in the present meta-analysis.

Motivation

Decreased motivation may provide a further alternative explanation for performance decrements on the second self-control task in dual-task paradigm experiments. One proposed model is that the ego-depletion effect is the result of reduced motivation to attain task goals. This may occur if a person perceives insufficient incentive to pursue the task goal, such as little reward or a lack of value attached to the outcome, relative to the effort demand of the task. The perceived imbalance between incentives and required effort is likely to lead to a drop in motivation. People will persist with tasks only so long as the reward or outcome is deemed worth the effort; when it is not, they will lose motivation and tend to desist. A motivation-only account of the ego-depletion effect would therefore predict that decreased regulatory capacity was independent of self-control resources. Evidence to support this explanation is evident in the mental fatigue literature, in which people are equally effective in performing short-term tasks, regardless of their state of mental fatigue, provided incentives are sufficient and their motivational state is high (Boksem, Meijman, & Lorist, 2006; Lorist, Boksem, & Ridderinkhof, 2005; Tops, Lorist, Wijers, & Meijman, 2004).

According to strength model theorists, a motivational account for regulatory failure on tasks is not inconsistent with model predictions. Proponents suggest that the effects of self-control resource availability and motivation on task performance may be interactive (Muraven & Baumeister, 2000). Reduced self-control resources as a result of engaging in self-control tasks may lead individuals to view task goals as unimportant due to the relatively costly demand that doing the task will place on remaining resources. This will result in reduced motivation on future tasks requiring self-control. Consistent with this premise, people may be able to overcome the debilitating effects of self-control resource depletion if they are given sufficient incentive to do so. Research has supported the moderating effect of motivational incentives, such as rewards and increasing the importance of task outcomes, on ego depletion (Muraven & Slessareva, 2003; Stewart et al., 2009). Even though resources may be lowered through prior exertion of self-control, they may be only partially depleted, leaving the potential for additional resources to be available (Muraven & Baumeister, 2000). However, motivation may only temporarily stem self-regulatory failure by causing people to tap into additional self-regulatory reserves, and "after a certain point, fatigue becomes insurmountable" (Baumeister et al., 2007, p. 353). A limited resource account of ego depletion therefore suggests that increased motivation can only stave off self-control failure to the extent that self-control resources remain available.

In summary, two competing explanations exist. A motivation-only account suggests that impaired performance on self-control tasks is purely a function of motivation and is not due to a limited resource. According to this approach, fatigue induced by initial self-control tasks leads to reduced motivation to perform subsequent tasks, probably due to the aversive nature of the tasks, but when motivation is high, performance can be maintained. In contrast, the strength model proposes that engaging in initial self-control tasks depletes self-control resources, at least partially, leading to fewer resources being available to perform subsequent tasks. However, increasing motivation to achieve a task goal may lead people to commit more of their increasingly limited self-control resources to engage in subsequent tasks, minimizing the impairment of performance. In the present analysis, we aimed to synthesize research that has examined motivation as a moderator of the ego-depletion effect and establish whether motivational manipulations, such as incentives, consistently minimize self-regulatory failure brought about by initial depletion. In particular, we make comparisons between depleted groups that receive motivational incentives and depleted groups that receive no incentives. This will provide some evidence that motivation can help overcome an ego-depleted state but may not provide sufficient evidence to resolve the competing motivation-only explanation and the motivation-plus-limited-resource explanation provided by the strength model.

Self-Efficacy

The self-regulatory failure observed in ego-depletion studies could be the result of reduced self-efficacy. Although people may view the goal of the task as attractive or important and believe they could achieve the goal if they exerted the required effort, they may perceive a reduced ability to reach it when in a depleted state. There is limited research examining the role of self-efficacy in ego-depletion studies. Wallace and Baumeister (2002) used bogus competence feedback on the initial task in the dual-task paradigm to induce high or low levels of self-efficacy. Identical patterns of ego depletion were found for participants across feedback conditions, leading Wallace and Baumeister to conclude that perceptions relating to ability are unlikely to be implicated in self-control resource depletion. This conclusion has been corroborated in studies that have found no relationship between self-reported self-efficacy and ego depletion in dual-task paradigm experiments (Baumeister et al., 2006; Finkel et al., 2006; Gailliot & Baumeister, 2007b). A possible reason for this is that reduced self-efficacy in one sphere may not necessarily transfer to reduced perceptions of ability toward a task in another, as in the dual-task paradigm. Self-efficacy may therefore be inadequate as an explanation for depletion because it does not transfer across task domains. Studies that have included measures of self-efficacy concurrent with ego depletion are included in the present meta-analysis to provide a

cumulative test of the effect of ego depletion on self-efficacy levels.

Affect

The active regulation of emotion or mood has been shown to deplete self-control resources and is a common means to invoke ego depletion in the dual-task paradigm (Baumeister et al., 1998; Bruyneel, Dewitte, Franses, & Dekimpe, 2009). This is because regulating affect requires an individual to overcome the innate tendency to display emotions in response to environmental stimuli. However, negative affect may also be implicated in the development of ego depletion. Tasks that require self-control are demanding and frustrating and may induce a negative affective state (Leith & Baumeister, 1996; Tice, Bratslavsky, & Baumeister, 2001). This may compel a person to actively cope with or attempt to repair the negative affect (Folkman & Moskowitz, 2000; Mayer & Gaschke, 1988). The coping process may reduce effort and motivation on subsequent self-control tasks and thus lead to impaired task performance. Studies including measures of affect as an additional dependent variable in the dual-task paradigm have not generally found a relationship between ego depletion and negative or positive affect (e.g., Baumeister et al., 1998; Bruyneel et al., 2009; Muraven et al., 1998). There are exceptions; for example Ciarocco, Sommer, and Baumeister (2001) and Stewart et al. (2009) found significant postdepletion increases in negative affect after controlling for baseline relative to nondepleted controls. The authors of these studies suggested that these increases served to indicate the aversive nature of depleting tasks. In the present meta-analysis, we provide a test of the effect of ego depletion on both negative and positive affect. The analysis may help resolve any inconsistency in the relationship between ego depletion and negative affect. A strength model interpretation would predict a null effect, as ego depletion is conceptualized as solely due to the depletion of self-control resources. In contrast, a coping hypothesis would predict a significant effect for ego depletion on negative affect. Finally, self-regulatory failure is not expected to undermine or alter levels of positive affect.

Experimenter Demand

Ego depletion may be an artifact of experimenter demand. Poorer performance on the second self-control task in dual-task paradigm experiments could be due to participants believing that they have sufficiently fulfilled the experimenter's demands after completing the initial task. In order to rule out this alternative explanation, studies have presented the tasks as separate experiments (e.g., Baumeister et al., 1998; Burkley, 2008; Fischer, Greitemeyer, & Frey, 2008; Seeley & Gardner, 2003; Vohs, Baumeister, & Ciarocco, 2005; Vohs & Faber, 2007) or unrelated tasks (e.g., Johns, Inzlicht, & Schmader, 2008; H. M. Wallace & Baumeister, 2002). Studies have also been conducted in which each task was administered by a different experimenter (e.g., Richeson & Shelton, 2003; Richeson, Trawalter, & Shelton, 2005; Vohs et al., 2008). The ego-depletion effect was found to be consistent in these studies and serves to falsify the experimenter demand explanation. We aimed to provide further confirmatory support for these findings in the present analysis by including the presentation of depleting tasks either as single or separate experiments or by the same or different experimenters as moderators of the ego-depletion effect.

Moderators of Ego Depletion

Although studies adopting the dual-task paradigm have generally supported the ego-depletion effect, the features of the tasks that deplete self-control resources or serve to measure depletion have not been systematically evaluated. Furthermore, the extent to which second self-control task performance is a function of the control condition used in the initial task is unknown. The features of these tasks may lead to variations in the strength of the ego-depletion effect and help resolve the inconsistencies observed in some studies (Stillman et al., 2009; Wright et al., 2007, 2008). Extraneous factors other than task features may also influence the size of the ego-depletion effect. For example, individuals with higher trait self-control may have an extended pool of self-control resources to draw from, which would increase their self-control capacity. We address these factors next.

Spheres of Self-Control

The dual-task paradigm permits an empirical test of the generality of the ego-depletion effect across different domains or spheres (Baumeister & Vohs, 2007). Baumeister et al. (2007) proposed that tasks requiring self-control be categorized into several domains or spheres: (a) controlling attention, (b) controlling emotions, (c) controlling impulses, (d) controlling thoughts, (e) cognitive processing, (f) choice and volition, and (g) social processing. Alternatively, tasks could be subsumed by more general categories that reflect the global processes demanded by the task, such as whether they require cognitive or affective processing. Regardless of the classification system, levels of ego depletion are expected to be equivalent in all spheres. This is important for the strength model, as it would confirm the hypothesis that acts of self-control draw energy from a common, global resource and that self-control failure is domain general and not an artifact of a particular sphere of task.

Notwithstanding the observed consistency of the ego-depletion effect across tasks in these spheres of self-control (Baumeister et al., 2007), there appears to be some inconsistency in the literature as to what exactly constitutes a self-control task. A typical feature of those tasks frequently adopted as depleting or dependent tasks in the dual-task paradigm is the requirement for the effortful suppression of an impulse or overriding of a habitual or dominant response. However, questions remain as to whether difficult tasks involving complex and challenging calculations (e.g., math problems and analytical reasoning tasks) demand self-control resources. Baumeister and colleagues (Baumeister et al., 1998; Muraven et al., 1998) contended that such tasks do not necessarily deplete self-control resources, because they involve the application of well-learned algorithms or heuristics rather than the exertion of overt control over the self to resist an impulse or override a dominant response. As a consequence, these tasks have been used as the nondepleting initial task in the dual-task paradigm (e.g., Muraven, Collins, & Nienhaus, 2002; Muraven, Shmueli, & Burkley, 2006, Study 1; Muraven et al., 1998, Study 3).

However, studies have also adopted difficult and complex tasks as the depleting task or dependent variable in dual-task paradigm

studies (e.g., Johns et al., 2008; Park, Glaser, & Knowles, 2008; Schmeichel, 2007; Wright et al., 2008). Such tasks may demand self-control resources for two reasons. First, they are often rated as high in difficulty, effort, and unpleasantness, such that self-control is required to resist the temptation to quit. For example, Wright et al. (2008) demonstrated impaired performance on regulatory tasks (e.g., incongruent Stroop color-naming task) as well as "nonregulatory" tasks (e.g., multiplication math task) after working on an initial depleting task. There is also evidence in other literatures, such as those for "mental" or "cognitive" fatigue (Ackerman & Kanter, 2009) and vigilance (See, Howe, Warm, & Dember, 1995). In these fields depletion effects have been demonstrated with tasks that are high in difficulty but do not share the typical features of self-control tasks. Second, tasks that require executive function place demands on cognitive systems (e.g., the need to maintain and update working memory). Such processes may share some features of the tasks, such as response inhibition, typically used in ego-depletion experiments. For example, memory updating tasks require people to constantly override the tendency to memorize items in a particular order and apply a different rule. This is the case in the reverse span memory tasks adopted by Schmeichel (2007, Study 2) that required the memorization of digits in a reverse order. This was considered more demanding of self-control resources relative to a control condition task that required one to merely hold information in memory. The evidence suggests that tasks high in difficulty and complexity also serve to deplete self-control resources.

These findings have two implications for the strength model. First, it seems that effect of self-control depletion on task performance may apply to a broader set of tasks and processes than originally proposed, including difficult or complex tasks. This is not inconsistent with the strength model, as such tasks require regulatory effort to resist the temptation to quit or apply complex rules that demand the inhibition of one process in favor of another. Second, tasks vary in difficulty and complexity and, therefore, are likely to vary in the extent to which they require self-control resources (Muraven et al., 2002). An aim in the present review was to examine whether this distinction acted as a moderator. That is, we aimed to classify tasks used in the depletion of self-control resources and as the dependent measure of self-control capacity in studies adopting the dual-task paradigm according to the demand they present to self-control resources (e.g., complexity) and to test this classification as a moderator of the ego-depletion effect.

Control Condition

Experiments adopting the dual-task paradigm have typically used a modified version of the depleting task that ostensibly does not require self-control resources as the control condition. For example, impulse control tasks require a person to override a well-learned or spontaneous response and consciously apply effort to perform the goal of the task. This might mean crossing out all instances of a particular letter in a passage of text but only when it is adjacent to certain other letters; resisting a tasty, tempting food and eating a bland, less appetizing food instead; or inhibiting the natural tendency to read the word rather than name the font color in an incongruent Stroop color-naming task. In each case the control condition simply requires that participants engage in an easier, less effortful version of the depleting task in which participants enact the dominant, impulsive response. So control participants in the aforementioned examples would be asked to cross out all instances of the letter without the inhibiting rules, given license to taste tempting foods, and provided with a version of the Stroop task in which the word and font color are congruent. Although some of the "easier" versions of these tasks may require a modicum of self-control to resist the urge to quit, as they are tedious and boring, they are considered far less demanding and are not expected to tax self-control resources to the same degree as the depleting versions.

However, some ego-depletion studies have adopted control tasks other than easier versions of the depleting task. For example, control participants have engaged in a task other than that administered to the depletion group, which is low in effort and ostensibly does not tax self-control resources (e.g., Burkley, 2008, Study 3; Muraven et al., 1998, Study 3). Alternatively, investigators have required all participants to engage in the same initial task (e.g., describing a target person from a minority group), which would require self-control only for people possessing a specific individual difference variable (e.g., motivation to avoid prejudice; e.g., Gailliot, Plant, et al., 2007; Gordijn, Hindriks, Koomen, Dijksterhuis, & Van Knippenberg, 2004; Muraven, 2008b; Park et al., 2008). There are also studies in which control participants did not engage in an initial task at all but sat passively before engaging in the dependent task (e.g., Baumeister et al., 1998, Study 3; Burkley, 2008, Study 2). Given the variety of approaches to evoking ego depletion and the tasks adopted in the control condition, it is important to establish whether the ego-depletion effect varies according to the type of task to which the depleting task is being compared. In the present meta-analysis, the type of control group is used as a moderator of the ego-depletion effect to test this hypothesis.

Personality and Individual Differences

The strength model focuses on state depletion of self-control resources. Self-control strength is viewed as vulnerable to depletion after acute bouts of self-regulatory effort; this subsequently limits short-term self-control capacity. However, numerous capacity-based theories of self-control also conceptualize self-control as a dispositional, traitlike construct that differs across individuals (Funder, Block, & Block, 1983; Metcalfe & Mischel, 1999; Muraven & Baumeister, 2000; Schouwenburg, 2004; Tangney et al., 2004; Wills & Dishion, 2004). For example, delay of gratification is viewed as a generalizable capacity to forgo short-term, alluring rewards in favor of greater, long-term rewards (Mischel, 1996; Mischel et al., 1989). This view has been incorporated into the strength model. Although all individuals are vulnerable to state depletion of self-control resources, individuals are proposed to differ in their overall self-control capacity (Baumeister et al., 2006). This implies that people high in dispositional self-control will have more resources at their disposal. Such individuals will have more resources remaining after engaging in a self-control task of a given duration and resource demand than will individuals lower in trait self-control. Trait self-control may therefore serve to insulate a person from the depleting effects of self-control tasks and moderate the ego-depletion effect. The proposed interaction between dispositional self-control measured on psychometric instruments and ego depletion has been tested

empirically, and results are inconclusive. Some studies have found a clear interaction effect (Dvorak & Simons, 2009; Gailliot & Baumeister, 2007b; Gailliot, Schmeichel, & Maner, 2007), and others have found no interaction (Gailliot & Baumeister, 2007b; Stillman et al., 2009). Although a resolution to these inconsistent findings through meta-analytic synthesis is needed, there are only a handful of effect sizes and few studies report the ego-depletion effect in both high and low dispositional self-control groups.

In addition, few studies have investigated the moderating effect of other traits and individual difference variables on ego depletion. Ego depletion has been shown to be positively associated with high other-orientations and low self-monitoring (Seeley & Gardner, 2003; Wan & Sternthal, 2008), higher levels of fluid intelligence (Shamosh & Gray, 2007), and higher levels of consideration of future consequences–immediate (Joireman, Balliet, Sprott, Spangenberg, & Schultz, 2008). The mechanisms behind these individual difference moderators can be explained through greater motivation to allocate self-regulatory resources among those with higher levels of the trait. For example, superior performance on self-control tasks under depleting conditions for individuals high in other orientation and low in self-monitoring has been attributed to greater motivation to meet the expectations of others and comply with normative standards (Seeley & Gardner, 2003; Wan & Sternthal, 2008). Individuals possessing fluid intelligence and consideration of future consequences–immediate may be predisposed to be more susceptible to the situational demands of tasks leading them to consume more self-control resources in the first task in the dual-task paradigm than are individuals in which these traits are absent (Joireman et al., 2008; Shamosh & Gray, 2007). In terms of mechanisms, individuals high in these traits may be more motivated to succeed and more likely to invest effort in the initial task at the expense of making resources available for subsequent self-control efforts. These findings indicate that the examination of individual differences in self-control may shed light on the factors that magnify or diminish the ego-depletion effect and provide information on underlying processes and boundary conditions. The inclusion of such moderators in future investigations using the dual-task paradigm is warranted.

Extending the Model

The view that self-control is akin to a limited resource in the strength model has given rise to additional related hypotheses. It is proposed that people will tend to conserve their resources when these resources are scarce, are able to improve their self-control capacity through practice or training, and are able to recover their self-control resources through rest or supplementation with glucose. These hypotheses are presented in the next section.

Conservation

The ego-depletion effect may be the result of a complete depletion of finite self-control resources; such depletion negates any possibility of subsequent acts of self-control. An alternative hypothesis is that self-control tasks only partially deplete resources and ego depletion occurs because people are either unable or unwilling to draw further from their reserves (Baumeister & Vohs, 2007; Muraven & Baumeister, 2000). One reason for this is that people conserve their limited self-control resources, particularly when they expect future exertion (Baumeister & Heatherton, 1996; Baumeister, Muraven, & Tice, 2000; Muraven & Baumeister, 2000). This is an adaptive strategy from a resource allocation point of view, as people are motivated to retain a residual level of their self-control resources in anticipation of future need. According to the strength model analogy, this is akin to an athlete conserving energy for a final effort toward the end of a race. Experiments in which participants were informed that they would be required to perform an additional third self-control task after the second self-control task have supported this hypothesis (Muraven, Shmueli, & Burkley, 2006; Tyler & Burns, 2009). Ego-depleted participants expecting another self-control task showed impaired performance on subsequent self-control tasks relative to depleted controls with no such expectations.

The conservation hypothesis is also consistent with a motivational account of ego depletion. Low self-control resources make the prospect of engaging in future self-control tasks more daunting, as it is more costly to allocate resources when they are scarce than when they are plentiful. As a consequence, motivation to engage in future self-control tasks will be decreased due to the high cost involved and low importance of the task goal relative to the importance of conserving self-control resources. This tendency to conserve is exacerbated when the prospective demands of future self-control are very high, such as when the prospect of a third self-control task is highlighted in the dual-task paradigm. The tendency to conserve will be greater and motivation toward the task will be diminished due to the expected future load. In this article, we aim to test whether the conservation hypothesis is supported across ego-depletion studies. We meta-analyze ego-depletion studies employing the dual-task paradigm that have included conditions in which participants were told to anticipate a third self-control task.

Training

In the previous section we introduced the hypothesis that training on self-control tasks improves self-control capacity and attenuates the ego-depletion effect (Baumeister et al., 1998). According to the strength model, just as a muscle increases in strength with training, the capacity to exert self-control will be heightened after repeated practice on self-control tasks. Support for this hypothesis has been provided in studies using self-control tasks in different spheres to train self-control. For example, participants required to engage in everyday tasks requiring self-control (e.g., improving posture, regulating mood, monitoring eating habits, and avoiding colloquial language) for a period of 2 weeks performed significantly better than untrained controls in a subsequent dual-task paradigm (Gailliot, Plant, et al., 2007; Muraven et al., 1999). Oaten and Cheng (2006a, 2006b, 2007) corroborated these results in a series of studies in which participants engaged in formal programs of academic study, physical exercise, and financial monitoring over a period of months. Participants engaging in the programs also reported being more effective in managing other everyday behaviors requiring self-control (Oaten & Cheng, 2006a, 2006b). These findings demonstrate that regular practice can help attenuate the ego-depletion effect. The mechanism for these improvements may be through increases in the amount of self-control resources available, an "extended pool" explanation, or, alternatively, through improved efficiency on the task, perhaps in the develop-

ment of more effective self-control "skills." The present analysis provides a cumulative test of the training hypothesis across studies.

Recovery

Periods of rest or relaxation may help to restore self-control resources after depletion and minimize the deleterious effects of depletion on subsequent task performance (Baumeister & Heatherton, 1996; Muraven & Baumeister, 2000). This is consistent with the muscle metaphor of the strength model: Muscles require a period of recovery after exertion before they can apply further force. Studies have tested this hypothesis by introducing rest or relaxation periods between tasks in the dual-task paradigm (Oaten, Williams, Jones, & Zadro, 2008; Tyler & Burns, 2008). Consistent with the hypothesis, findings indicated that ego-depleted individuals given the opportunity to rest or relax exhibited superior second-task performance relative to nonrested depleted controls. Of note, Tyler and Burns (2008) found evidence for a "dose effect," such that the restoration of self-control capacity is proportional to the duration of the recovery period. Given this finding, it follows that variability in the interim period between tasks in the dual-task paradigm may account for some of the variability in the ego-depletion effect across studies. For example, experiments in which participants are required to complete questionnaires or take a break during the intertask interim period may provide greater opportunity to recover self-control capacity relative to experiments in which participants proceed immediately to the second task. In this article, we test the recovery hypothesis by subjecting studies including rest or relaxation periods in a dual-task paradigm to a meta-analytic synthesis. As an additional test, we examine whether the inclusion of an intertask interim period moderates the ego-depletion effect.

Glucose and Glucose Supplementation

In search for physiological mechanisms for self-control resource depletion, Gailliot and coworkers (Gailliot & Baumeister, 2007a; Gailliot, Baumeister, et al., 2007) provided preliminary evidence that blood glucose may be the control mechanism for the depletion of self-control reserves. These studies demonstrated that ego depletion coincides with decreases in blood glucose and glucose supplementation attenuates the ego-depletion effect relative to a sweetened placebo (DeWall, Baumeister, Gailliot, & Maner, 2008; Dvorak & Simons, 2009; Gailliot, Baumeister, et al., 2007; Gailliot, Peruche, Plant, & Baumeister, 2009; Masicampo & Baumeister, 2008). On the basis of these findings, Gailliot and coworkers suggested that the strength model of self-control was more than just a metaphor and that self-control resource depletion occurred concurrent with the utilization of fuel substrates in the body. In the present meta-analysis, we test the consistency of blood glucose as an analogue for self-control depletion and the potential of glucose supplementation to moderate the ego-depletion effect.

The Present Analysis

The past decade has seen a proliferation in research on self-regulatory failure from the perspective of the strength model, and a cumulative synthesis of these research findings is timely. At the most basic level, the analysis will be expected to summarize the overall effect of self-control resource depletion on task performance. A cursory glance at trends in the literature and narrative reviews suggests that the effect will be present, notwithstanding a minority of studies that have found nonsignificant effects. However, it is important to evaluate the extent of the variability in the effect and identify the moderator variables that may resolve this variability. The evaluation of these moderators may assist in determining the adequacy of the strength model in explaining ego depletion, resolving any inconsistencies in the literature, and evaluating whether competing or complementary explanations can offer insight into the variation in the effect.

Overall Ego-Depletion Effect

The effect size of interest is the overall averaged effect of ego depletion on self-control task performance corrected for sampling error variability across published studies using the dual-task experimental paradigm. The effect of ego-depleting self-control tasks on participants' second task performance relative to that of nondepleted controls will be the key dependent variable. The strength model predicts that the average ego-depletion effect will be significant and homogeneous across studies.

Additional Dependent Variables

We test the effect of ego depletion on seven additional dependent variables: effort, positive affect, negative affect, perceived difficulty, subjective fatigue, self-efficacy, and blood glucose. In keeping with the highly aversive and effortful nature of self-control tasks, significant effect sizes for the effort, perceived difficulty, subjective fatigue, and negative affect variables are expected. Consistent with previous tests of ego depletion on positive affect, null or weak effects for ego depletion on this variable are expected. The effect of ego depletion on self-efficacy is less consistent and has not been frequently tested. A plausible hypothesis is that self-efficacy may be implicated in the ego-depletion effect because reduced resources may lower estimates of future ability to exert self-control, although this has not been supported empirically. Finally, the analysis tests whether self-regulatory failure brought about by ego depletion coincides with reduced blood glucose levels. This may provide evidence that substrate use serves as a physiological indicator of self-control resource depletion.

Analysis of Moderators

Several moderators hypothesized to magnify or diminish the overall ego-depletion effect are included in the analysis. In this article, we test whether the sphere of depleting self-control task in dual-task paradigm experiments moderates the ego-depletion effect. Baumeister et al. (2007) proposed that self-control tasks from different spheres would be equally depleting because self-control draws from a single, global resource. An alternative hypothesis is that some spheres of self-control may be more demanding of self-control resources than others, so the moderator analysis may identify spheres that place a greater burden on self-control resources. We also evaluate whether the sphere of the dependent task used as an index of ego depletion moderates the effect. Although little variance in the ego-depletion effect is expected across these dependent tasks, it is possible that some of these tasks may place

fewer demands on self-control resources or be less effortful than others, leading to less of a decrement in performance. We also test the variability of the ego-depletion effect across frequently used depleting and dependent self-control tasks. This information will provide some indication as to whether these types of task are equally effective in inducing and measuring ego depletion. The hypothesis that tasks vary in the extent to which they deplete self-control resources has not been studied systematically, and the present study is the first to synthesize studies on self-control resource depletion according to task domain and type. In addition, we evaluate whether using depleting and dependent tasks from the same or different spheres in the dual-task paradigm moderates the ego-depletion effect. If the proposed generality of the ego-depletion effect holds, the size of the effect should be invariant regardless of whether or not the depleting and dependent tasks are "matched" on task sphere. This analysis also provides an indication of the extent to which these studies provide an effective test of the generality hypothesis.

Task complexity is also included as a moderator. The aim in this analysis is to resolve the apparent contradiction in the literature as to whether tasks that are difficult or challenging, but do not ostensibly require overriding a well-learned response, deplete self-control resources. In addition, it is expected that the duration of depleting task in the dual-task paradigm will be linearly related to the size of the ego-depletion effect. We also test whether presenting tasks as single or separate experiments or by the same or different experimenters moderates the overall ego-depletion effect. The purpose in these analyses is to rule out the alternative explanation that the ego-depletion effect is due to experimenter demand.

The analysis evaluates whether the dependent task is a behavioral or self-report measure of ego depletion. We expect the ego-depletion effect to be significant in both groups, but a logical prediction would be that the ego-depletion effect will be inflated in the group of studies using self-reported dependent variables due to the increased measurement error associated with such measures (Westholm, 1987).

The effect of the nature of the task used in the control condition alongside the depleting task is also be evaluated as a moderator. This analysis provides evidence on whether use of a modified, "easier" version of the self-control task, a different task altogether, or the same task alongside an individual difference variable that renders the task more taxing for some individuals is equally effective as use of comparison groups in ego-depletion experiments. We also test whether cognitive processing tasks that require complex processing result in greater ego depletion than tasks that are simpler and present fewer demands. Finally, we compare the ego-depletion effect in tests originating in the dominant Baumeister laboratory relative to tests from other laboratories. No difference is expected in the overall ego-depletion effect across the laboratory moderator groups.

Testing Strength Model Hypotheses

In this article, we conduct a meta-analysis of studies that have tested additional hypotheses derived from the strength model: the conservation, training, and recovery hypotheses. For the conservation hypothesis, we test whether the expectation of future demands on self-control resources will diminish self-regulatory capacity indicating the tendency to conserve resources. The role of using incentives and highlighting the importance of task outcomes as means to reduce the ego-depletion effect is also evaluated. This evaluation determines whether motivation mitigates the self-regulatory failure brought about by engaging in initial self-control tasks. For the training hypothesis, we meta-analyze studies that have tested the ego-depletion effect in participants provided with a period of training on self-control tasks prior to engaging in the dual-task paradigm. For the recovery hypothesis, we meta-analyze studies that have included a period of rest or relaxation or an interim period between the first and second self-control tasks in the dual-task paradigm. We predicted that the ego-depletion effect would be attenuated through the provision of motivation-enhancing strategies, training on self-control tasks, or a recovery period after the initial depleting task. By analogy, the ego-depletion effect was expected to be exacerbated if there was an expectation of future acts of self-control. Finally, the role of glucose supplementation as a means to mitigate the deleterious effects of self-control resource depletion on subsequent task performance is examined. It was anticipated that ego-depleted participants' self-control task performance would be improved by the provision of glucose relative to a sweet placebo.

Method

Literature Search

Published research articles were located via a search of electronic databases—ERIC, Embase, ISI Web of Science (Science Citation Index Expanded, Social Science Citation Index Expanded), Medline, PsycARTICLES, and PsycINFO—covering the literature from 1998 (the year of Baumeister et al.'s and Muraven et al.'s initial research articles on ego depletion) until April 1, 2009. The following search terms in various combinations were used for all searches: *ego depletion, ego energy, self-control,* and *self-regulation,* with subterms *depletion, failure, limit, resources,* and *strength*. The reference sections of the retrieved articles considered for this review were scrutinized for additional studies. We also examined the reference sections of key narrative reviews of the literature on ego depletion and the strength model of self-control (Baumeister, 2002, 2003; Baumeister et al., 2000, 2006; Baumeister, Sparks, Stillman, & Vohs, 2008; Baumeister & Vohs, 2007; Baumeister et al., 2007; Gailliot & Baumeister, 2007a; Muraven & Baumeister, 2000; Schmeichel & Baumeister, 2004; Vohs & Baumeister, 2004). In addition, we searched for articles in key social psychology journals and their repository of articles published online in advance of print.

Inclusion Criteria

Studies were required to provide an experimental test of the ego-depletion effect using variants of the dual-task paradigm outlined by Baumeister et al. (1998). For the overall ego-depletion effect, studies had to include a quantifiable measure of task performance for the second self-control task in the experimental group that received the ego-depleting task and a nondepleted control group. Studies that included a continuous or discrete (e.g., median split) individual difference moderator of the ego-depletion effect were considered eligible if effect size data for the depleted and nondepleted groups were available for the main effect of ego

depletion independent of the moderator (e.g., DeWall, Baumeister, Stillman, & Gailliot, 2007, Study 4; Joireman et al., 2008, Study 3; Richeson et al., 2005, Study 1; Seeley & Gardner, 2003). In some cases, the initial depleting task was identical for all participants and depletion was evoked on the basis of an individual difference variable. For example, Gailliot, Plant, et al. (2007) divided their sample into those with high or low scores on internal motivation to respond without prejudice and then presented all participants with a task requiring them to describe a homosexual target and avoid stereotypical statements. The task was expected to deplete self-control resources only in low-motivation participants, because suppressing stereotypes was considered difficult and effortful for people who did not regularly attempt to control prejudiced thoughts. In such cases the individual difference variable served as the depletion condition (e.g., Gailliot, Plant, et al., 2007; Segerstrom & Nes, 2007; Vohs et al., 2005). To ensure that the use of individual difference variables to deplete self-control resources did not bias the overall ego-depletion effect, we included this as an additional moderator variable in the meta-analysis. Some studies included experimental manipulations expected to moderate the ego-depletion effect (e.g., Tyler & Burns, 2008; H. M. Wallace & Baumeister, 2002; Wan & Sternthal, 2008). In such cases, the ego-depletion effect was calculated for depleted and nondepleted participants in the condition where the moderator was absent. This represents a simple, unattenuated test of the ego-depletion effect. For example, Tyler and Burns (2008) introduced an experimental condition of relaxing music between the initial and second tasks in the dual-task paradigm to aid relaxation; control participants received no music. In this case, the ego-depletion effect was calculated from the dependent task performance of depleted and nondepleted individuals assigned to the music-absent condition.

Nonexperimental studies assessing the effect of self-reported, trait measures of self-control on task performance and studies that did not use the dual-task paradigm or include a nondepleted control group were rejected (e.g., Fennis, Janssen, & Vohs, 2009, Study 6; Finkel & Campbell, 2001; Muraven, 2008a; Muraven, Collins, Shiffman, & Paty, 2005; Muraven et al., 1998, Study 4; Neubach & Schmidt, 2008; Oaten et al., 2008; Schmeichel & Zell, 2007; Schmidt, Neubach, & Heuer, 2007; Tangney et al., 2004; J. C. Wallace, Edwards, Shull, & Finch, 2009). The only two exceptions to this were studies that included nonbehavioral or judgment measures in place of the second task and studies that did not include a nondepletion control group but provided tests of the conservation, training, and recovery hypotheses from the strength model. Studies using a nonbehavioral or judgment dependent variable were included because such measures not only serve as an analog of ego depletion but also reflect decisions likely to place a demand on self-control resources (e.g., Burkley, 2008; Fischer, Greitemeyer, & Frey, 2007). However, such measures may be unsuitable as the initial depleting task in the dual-task paradigm. To check that the inclusion of these studies did not bias the overall ego-depletion effect, we also included dependent measure type (behavioral vs. nonbehavioral or judgment) as a moderator of the overall ego-depletion effect.

Finally, studies had to contain sufficient statistical information, such as cell means and standard deviations, F ratios, t statistics, zero-order correlations (r), or effect size statistics (e.g., Cohen's d, η^2), to calculate an estimate of effect size. Missing data for studies that were otherwise eligible were requested by contacting the authors. Finally, eligible studies were systematically screened for duplicates to eliminate bias due to duplicate study effects (Wood, 2008).

Meta-Analytic Strategy

We used Hunter and Schmidt's (1994) methods for meta-analysis to correct effect sizes for sampling error variability.[2] Monte Carlo simulation studies have supported the adoption of a random effects model because it permits the generalization of corrected effect sizes to the population (Field, 2003; Hunter & Schmidt, 2000; Kisamore & Brannick, 2008). The effect size metric employed in the current analysis was Cohen's d, which represents the standardized mean difference score for experimental (ego depletion) and control (nondepletion) groups in studies adopting the dual-task paradigm. Effect sizes were calculated directly from the means, standard deviations, and sample sizes for the experimental and control groups wherever possible. Standard formulas were used to compute the effect size statistic from F ratios, t tests, or zero-order correlation coefficients (DeCoster, 2004; Hullett & Levine, 2003). In cases where multiple methods for effect size calculation were available, we used the test most closely based on the means, standard deviations, and sample sizes (DeCoster & Claypool, 2004).

In addition to producing the averaged overall effect size corrected for sampling error (d^+), we calculated 95% confidence intervals (CI_{95}) with the standard error of the mean effect size to test the accuracy of effects. We also computed the fail-safe sample size (N_{FS}), which represents the number of unpublished studies with null findings that would have to exist in the researchers' file drawers to reduce the effect size to a zero value (Rosenberg, 2005). If the number of "null finding" tests of an effect is sufficiently large, the researcher can be confident that the chance of such a number of studies existing is negligible. Rosenberg suggested a critical value of $5N + 10$ for the N_{FS}.

In addition, the percentage variance in the effect sizes across studies attributed to within-study sampling error variability relative to overall between-study variance in the effect size was calculated. This ratio of variance is an important first step in establishing the homogeneity of the effect size, that is, whether the vast majority of the variance in the effect across studies can be accounted for by sampling error (Aguinis & Pierce, 1998). Hunter and Schmidt (1994) have proposed that the proportion of variance attributed to within-study sampling variance should exceed 75% for an effect size to be considered homogeneous. A formal test of the relative homogeneity of an effect is given by Cochran's (1952) Q statistic. The Q statistic is a relatively conservative test and can lead to Type II errors (i.e., increased probability of accepting as homogeneous sets of studies that have substantial heterogeneity), so we adopted the 75% rule in the cases where the Q statistic was

[2] We also conducted our meta-analyses using a fixed-effects meta-analytic method (Hedges & Olkin, 1985). Effect sizes and confidence intervals computed for the overall ego-depletion effect and the moderator group, additional variables, and strength model hypotheses analyses were not appreciably different from those produced with a random effects model. Data for the fixed-effects analyses are available on request from the first author.

significant (Sagie & Koslowsky, 1993; Sánchez-Meca & Marín-Martínez, 1997).

As the number of studies (k) varies across meta-analyses, the Q statistic cannot be compared across analyses, so we also calculated the I^2 statistic and its confidence interval as an alternative (Higgins, Thompson, Deeks, & Altman, 2003). This represents a measure of true heterogeneity in the effect size in question expressed as a percentage and is easily interpretable, with levels of 25%, 50%, and 75% representing low, medium, and high levels of heterogeneity respectively (Higgins & Thompson, 2002). Should the I^2 value exceed 25% with a wide confidence interval that does not have a zero lower limit, it is likely that substantial heterogeneity in the effect size exists (Huedo-Medina, Sánchez-Meca, Marín-Martínez, & Botella, 2006). This would suggest that the effect may be influenced by extraneous moderator variables.

Finally, we treated the effect size data for the overall ego-depletion effect and all moderator and additional variable subanalyses for statistical outliers. We adopted Grubbs' (1950) test to identify outliers in accordance with Barnett and Lewis's (1994) recommendations. Identified outliers were set at the value of the next closest effect size in the data set.

Moderator Coding

Sphere of self-control task. We conceptualized sphere of depleting and dependent tasks in three different ways: as specific and distinct spheres, as suggested by Baumeister et al. (2007); as global spheres, according to the demands placed on cognitive or affective processing systems;[3] and as tasks frequently used in the dual-task paradigm. Baumeister et al.'s suggested spheres of self-control are based on the features of the task: controlling attention, emotions, thoughts, and impulses, cognitive processing, choice and volition, and social processing. Tasks requiring attention control involved focusing attention and disregarding distractions, such as watching the central figure in a video while ignoring words displayed in a corner of the screen (e.g., Fischer et al., 2008, Study 1; Schmeichel & Vohs, 2009, Study 2). Controlling emotions tasks demanded the active suppression of emotional responses, such as requiring participants to avoid expressing emotions when watching emotionally appealing or aversive videos (e.g., Baumeister et al., 1998, Study 3; Hofmann, Rauch, & Gawronski, 2007). Impulse control tasks demanded that participants resist gratifying courses of action or override well-learned habits, such as resisting tempting foods (e.g., DeWall et al., 2007, Study 1; Geeraert & Yzerbyt, 2007, Study 1b) or suppressing the urge to name the target word instead of the typeface color in Stroop color-naming tasks (e.g., Bray, Ginis, Hicks, & Woodgate, 2008; Webb & Sheeran, 2003, Study 1). Controlling thoughts tasks demanded that participants suppress unwanted thoughts; an example is Wegner, Schneider, Carter, and White's (1987) paradigm that requires participants to avoid thinking of a "white bear" (e.g., Burkley, 2008, Studies 3 and 4; Tyler, 2008, Study 4). Tasks requiring choice or volition involved participants making a choice or decision between options in numerous contexts (e.g., consumer choices or choosing to write an essay in a forced-choice paradigm; see, e.g., Baumeister et al., 1998, Study 2; Bruyneel, Dewitte, Vohs, & Warlop, 2006, Studies 1, 2, and 3). Cognitive processing tasks involved exerting effort to maintain a high degree of executive functioning or processing information, as when working on challenging anagram, memory span, or counting tasks (e.g., Park et al., 2008; Schmeichel, 2007, Study 3; Wright et al., 2007, Studies 1 and 2). Social processing tasks required the processing of social information that might involve searching for appropriate social cues, such as when suppressing stereotypes, resisting persuasion, or engaging in high-maintenance social interactions (e.g., Burkley, 2008, Study 1; Finkel et al., 2006; Gordijn et al., 2004, Studies 2 and 4; Richeson & Shelton, 2003). Moderator coding was initially conducted by the three lead authors. An independent judge familiar with self-control tasks and the dual-task paradigm then performed the classification independently. The agreement of the judge's classification with those of the coauthors was high ($\kappa = .81$, $p < .001$). Discrepancies were discussed with the judge, and a consensus decision was made to resolve the ambiguity.

Depleting and dependent tasks were also subjected to a global classification according to the extent to which they placed demands on affective or cognitive processing or a combination of the two. Tasks requiring the control of emotions and impulses were classified as affective. Controlling attention and thoughts, choice and volition, and cognitive processing tasks were classified as cognitive. Finally, social processing tasks were classified as requiring both affective and cognitive processes. The latter was justified on the basis that such tasks demand a degree of cognitive control or regulation but also the suppression of impulses or emotions. For example, tasks that require participants to identify relational cues involve a cognitive process to focus attention on the appropriate cue and an affective process to avoid the impulse or temptation to fall back on heuristic processing (Tyler, 2008).

Frequently used tasks. We also created a moderator variable for tasks frequently used to deplete and measure self-control in the dual-task paradigm. Tasks that had a frequency of use greater than 10 in the sample of studies were considered eligible. Frequently used depleting tasks were the video-watching affect regulation, video-watching attention control, crossing out letters, modified Stroop (1935), and Wegner et al.'s (1987) "white bear" thought-control tasks. Frequently used dependent tasks included the hand-grip, solvable anagram, food taste test, math or mental arithmetic, and modified Stroop (1935) tasks.

A taxonomy of self-control-depleting and self-control-dependent tasks was developed to summarize the coding of tasks in each sphere of self-control. The taxonomy, provided in Appendix A, is organized with depleting tasks in the top half and dependent tasks in the bottom half.[4] The tasks are categorized according to Baumeister et al.'s (2007) spheres of self-control at the subordinate level, with global affective, cognitive, and combined affective and cognitive spheres as higher order categories. A brief description of the task, studies that have adopted the task, and frequency of task use are included in each cell of the table. The taxonomy is intended as a resource with which to identify the category and frequency of use of the self-control tasks adopted as depletion and dependent tasks in dual-task paradigm experiments.

Duration of depleting task. The longer the duration of the depleting self-control task in the dual-task paradigm, the greater the expected impairment of performance on the second task. This

[3] We thank an anonymous reviewer for this suggestion.

[4] Appendices A, B, and C are made available as online supplementary materials (http://dx.doi.org/10.1037/a0019486.supp).

is because the amount of self-control resource consumed is assumed to be proportional to the time spent exerting self-control. We extracted depleting task duration in minutes from studies that reported these data. In cases where data on task duration were missing but a standardized depleting task was used (e.g., modified Stroop task), the task duration was inferred from the average duration for that task across studies reporting duration data.

Interim period. As few studies reported the precise time period between the two tasks in the dual-task paradigm, we aimed to test whether the type of intertask interim activity moderated the ego-depletion effect. Studies were therefore classified on the basis of the activities performed during the interim period. Studies were classified as those that reported no activities during the interim period, those that required participants to complete questionnaires (e.g., mood scales, manipulation check items), and those that required participants to engage in a filler task or reported a rest period between tasks. We predicted, in accordance with the recovery hypothesis, that studies reporting no interim period would provide less opportunity for participants to recover their self-control resources, leading to a larger ego-depletion effect. In contrast, participants required to complete questionnaires or filler tasks or prescribed a period of rest between tasks were expected to have greater chance for recovery and a comparatively smaller ego-depletion effect.

Experiment presentation. We also tested whether presenting tasks in the dual-task paradigm as single or separate experiments or by the same or different experimenters moderated the overall ego-depletion effect. Studies making an explicit statement that the tasks were presented as separate experiments were coded as one moderator group, and those making no explicit distinction were assumed to have presented the tasks as a single experiment and were coded as the other moderator group. In addition, studies that reported using different experimenters to administer the self-control tasks formed one moderator group, and studies using the same experimenter formed the other moderator group.

Type of dependent task. We conducted a moderator analysis to evaluate whether nonbehavioral or judgment dependent self-control measures in the dual-task paradigm were as vulnerable as behavioral measures to the ego-depletion effect. Studies were therefore coded according to whether they used a behavioral measure, such as performance of a self-control task, or used a nonbehavioral or judgment measure that was indicative of self-control effort. Examples of nonbehavioral or judgment dependent measures include subjective ratings of a target person, with responses analyzed for prejudiced or aggressive responses (e.g., Muraven, 2008b; Stucke & Baumeister, 2006), or self-reported evaluations that require suppression of well-learned tendencies, such as being modest and self-effacing rather than being narcissistic or exaggerating ability (e.g., Fischer et al., 2007; Vohs et al., 2005, Study 8).

Matched depleting and dependent tasks. Studies were coded according to whether the depleting and dependent self-control tasks in the dual-task paradigm were from the same or different spheres in accordance with to the previously cited criteria for specific and global spheres of self-control. We therefore developed two moderator groups. Studies that adopted depleting and dependent tasks from the same specific sphere (controlling emotions, thoughts, impulses, and attention, choice and volition, cognitive processing, and social processing) or global sphere (affective, cognitive, or combined affective and cognitive) were coded as matched, and those adopting tasks from different spheres were coded as unmatched.

Control condition. We coded studies according to the type of control condition that was adopted in the dual-task paradigm. The majority of studies used modified, easier versions of the depleting task that did not require the overriding of an impulsive or well-learned response. Some studies used an alternative task that was ostensibly easier and required less self-control than did the depleting task. For example, Muraven et al. (1998, Study 3) used Wegner et al.'s (1987) white bear thought control paradigm to deplete self-control resources and compared these participants with a control group that solved math problems. Muraven et al. argued that the active suppression of unwanted thoughts demanded more self-control resources than math problems, as the latter did not require the active suppression of a dominant response. It is, nevertheless, possible that the math problems still required some degree self-control in that participants had to resist the urge to quit. The adoption of such tasks in the control condition may require a degree of self-control but less than that required by the depleting tasks in the experimental condition. This may serve to moderate the ego-depletion effect, so we coded studies into moderator categories according to their use of easier versions and alternative tasks in the control condition. We also coded studies that used the same initial task but included an individual difference variable to evoke depletion. For example, Gordijn et al. (2004) segregated their sample into individuals scoring low and high on a motivation to respond without prejudice measure, and participants in both groups were then asked to describe a person from a minority group while suppressing stereotypes. Consistent with predictions, the low-motivation group exhibited greater ego depletion on the second task than did the high-motivation group. Some studies adopted a design in which the initial task was absent for control participants (Baumeister et al., 1998, Study 3; Burkley, 2008, Study 2). However, too few studies ($k = 2$) were available for us to include this as a moderator category.

Task complexity. Although self-control tasks share a similar domain or sphere, they are quite variable in their specific features, making it difficult to evaluate whether these features may be more demanding than others of self-control resources. For example, it is difficult to establish whether resisting tempting foods in an ostensible taste test is more demanding or effortful than resisting the discomfort in the forearm muscles while holding a handgrip apparatus. However, some tasks in the cognitive processing domain with clear common features have been classified as more or less demanding due to their complexity and the type of processing required. Schmeichel's (2007) experiments on the resource-depleting effect of tasks requiring executive functioning identified tasks that varied in the extent and number of processes required; it was proposed that the level of complexity was proportional to the degree of ego depletion evoked. For example, executive functioning tasks such as recalling a set of digits in the order in which they were presented were less effortful and required less self-control resources than tasks that required the recall of digits in reverse order. This is because maintaining figures in memory as in the forward span task does not require other control processes, such as updating and ignoring or inhibiting competing information, as in the reverse span task. Similarly, Wright et al. (2008) suggested that simple math calculations involving single arithmetic operations

(e.g., multiplication) require less effort and place less burden on self-control resources than mixed-operation calculations, as they do not require the need to suppress competing processes: "A single operation challenge . . . obviates the need to inhibit one operational impulse (e.g., that to add) in favor of another (e.g., that to divide) and, thus, eliminates a source of regulatory demand" (Wright et al., 2008, p. 130).

A substantial subset of the present sample of studies ($k = 36$) adopted dependent self-control tasks that varied in their complexity and could be categorized accordingly. These could then be used as moderator groups to test the hypothesis that simple tasks require less self-control resources than complex tasks do. This hypothesis is consistent with the strength model, which suggests that dependent tasks with greater regulatory demand would lead to increased performance impairment and therefore more ego depletion after working on a depleting task. Studies that adopted tasks requiring rote memory, recall, or single arithmetic operations were classified as simple self-control tasks. These tasks included rote memory (e.g., Gailliot, Schmeichel, & Baumeister, 2006, Study 7), addition and multiplication (e.g., Mead, Baumeister, Gino, Schweitzer, & Ariely, 2009, Study 1; Stewart et al., 2009; Vohs et al., 2005, Study 1), and forward span recall (e.g., Schmeichel, 2007, Study 2). Tasks that required multiple cognitive processes such as encoding, memory maintenance and updating, and multiple arithmetic operations were classified as complex. These included solvable anagrams (e.g., Gailliot, Baumeister, et al., 2007, Study 8; Gordijn et al., 2004, Study 5); reading, sentence, and reverse span memory tasks (e.g., Johns et al., 2008, Studies 1 and 4; Schmeichel, 2007, Studies 1 and 2); Graduate Record Examination reasoning (e.g., Fennis et al., 2009, Study 2; Finkel et al., 2006, Studies 2 and 3; Gailliot et al., 2006, Study 7); and mixed-operation arithmetic calculation tasks (Wright et al., 2008). We again used an expert judge to corroborate our classification, and interrater reliability for the classifications was very high ($\kappa = .89$, $p < .001$). There were insufficient numbers of studies ($k = 9$) in the cognitive processing sphere for us to conduct a meta-analysis with depleting task complexity as a moderator.

Source laboratory. The strength model was developed and extensively tested by Baumeister and colleagues (Baumeister et al., 1998; Muraven et al., 1998). The model comprised the largest number of tests of the ego-depletion effect emanating from a single research group in the present sample of studies. We therefore considered it prudent to include source laboratory as a moderator variable to detect any potential variation in the effect in studies originating in the laboratories of Baumeister and his known collaborators (DeWall, Gailliot, Muraven, Schmeichel, and Vohs) and studies from other investigators' laboratories. Studies were coded if they emanated from the Baumeister laboratory or those of his collaborators ($k = 98$) or another laboratory ($k = 100$) according to coauthorship and known prior affiliation.

Moderator Analysis

Analytic strategy. The influence of categorical moderator variables on the ego-depletion effect was evaluated by segregating studies on the basis of the moderator and conducting separate meta-analyses in each moderator group. The moderator was considered effective if the average corrected effect sizes calculated in each moderator group were significantly different, as evidenced by no overlap in the CI_{95}. Moderation was further supported if the moderator resulted in a narrowing of the CI_{95}, an increase in the variance accounted for by sampling error variability, and a decrease in the I^2 statistic. One of the moderator variables (depleting task duration) was continuous, and we tested its effect on the ego-depletion effect size using linear regression.

Relations between moderators. We also examined relations between the significant moderator variables to identify potential confounding effects among the moderators of the ego-depletion effect (DeCoster, 2004; Lipsey, 2003). As the majority of the moderators in the present study were categorical, we conducted chi-square analyses on two-way categorical tables to evaluate the strength of the relationships between the variables. Relations between the one continuous moderator (depleting task duration) and the categorical moderators were evaluated by calculation of the average values for the continuous moderator at each level of the categorical variable followed by a one-way ANOVA to test the strength of the relationship. A statistically nonsignificant chi-square or F ratio indicates that the effect of one moderator variable on the dependent variable (ego depletion) is likely to be independent of that of the other moderator variable. We used a conservative p value of .01 to evaluate the significance of the relations. In the event of a significant association between moderators, we examined the categorical tables to identify the source of the variation. Where appropriate, we conducted follow-up meta-analyses of the ego-depletion effect in groups of studies determined by the crossing of the related moderator variables.

Additional Dependent Variables and Alternative Hypotheses

Studies measuring additional dependent variables alongside measures of task performance in ego-depletion studies adopting the dual-task paradigm were also subjected to meta-analytic synthesis. In particular, studies including self-report measures of effort, positive and negative affect, perceived difficulty, subjective fatigue, self-efficacy, and blood glucose for experimental (ego-depleted) and control (nondepleted) groups were identified and effect sizes calculated. These additional variables were not measured in all studies or were unavailable in some cases, so the samples for these analyses were invariably subsets of the sample used to calculate the overall ego-depletion effect.

Positive and negative affect were tapped with previously validated (e.g., BMIS; Mayer & Gaschke, 1988; PANAS; Watson, Clark, & Tellegen, 1988) and author-developed measures of mood and affect. Subjective fatigue and perceived difficulty were invariably measured on self-report scales developed by the study authors. Measures of self-efficacy included standardized measures (e.g., Generalized Self-Efficacy Scale; Schwarzer & Jerusalem, 1995) as well as those developed by the study authors. A content analysis of the items used in the self-efficacy instruments revealed considerable commonality in content with measures focusing on perceived competency and expectations of success in performing the target task. A judge employed to independently code the dependent measures demonstrated strong agreement with our classification ($\kappa = .95$, $p < .001$). Discrepancies were resolved using the method we had used previously. Studies measuring the effect of ego depletion on blood glucose levels used commercially available electronic blood glucose analyzers.

Testing Strength Model Hypotheses

Conservation. Studies testing the conservation hypothesis were required to provide sufficient data for us to calculate a standardized difference in postdepletion performance on the second self-control task for participants told to expect an additional self-control task and control participants not informed of an additional task. Larger effect sizes reflected greater levels of ego depletion in participants anticipating future self-control. We also tested the effect of strategies to increase motivation on the ego-depletion effect across studies. We therefore meta-analyzed the second-task performance of ego-depleted participants provided with either a motivational intervention or no intervention in the dual-task paradigm. Motivational interventions included providing monetary incentives to complete the second task (Muraven & Slessareva, 2003), framing the second task as important or meaningful (Muraven & Slessareva, 2003), and presenting the second task in an autonomy-supportive manner to facilitate intrinsic motivation (Moller, Deci, & Ryan, 2006; Muraven, Gagne, & Rosman, 2008). Larger effect sizes indicated that motivation was effective in promoting better performance on self-control tasks.

Training. The criterion for studies eligible for the training hypothesis analysis was the inclusion of an experimental manipulation that required participants to engage in a period of practice with self-control tasks prior to being subjected to an ego-depletion manipulation using the dual-task paradigm. Self-control was trained with diverse tasks, such as speech modification (e.g., using "yes" and "no" only and no colloquialisms; Gailliot, Plant, et al., 2007), use of the nondominant hand (Finkel, DeWall, Slotter, Oaten, & Foshee, 2009), maintaining posture, mood regulation, monitoring eating habits (Muraven et al., 1999), impulse control tasks like the Stroop test or an aversive mouth rinse (Hui et al., 2009), physical exercise (Oaten & Cheng, 2006b), financial self-management (Oaten & Cheng, 2007), and academic study (Oaten & Cheng, 2006a). Studies reporting differences in second self-control task performance between trained depleted participants and untrained depleted controls were included. Larger effect sizes represented superior performance on self-control tasks as a result of training.

Recovery. We aimed to test the variation of the ego-depletion effect in studies that manipulated the duration of the intertask rest or relaxation period in the dual-task paradigm. However, we could locate only two studies ($k = 4$) that tested this effect (Oaten et al., 2008; Tyler & Burns, 2008). This number was considered insufficient for conducting a moderator analysis. An indirect test of the recovery hypothesis was offered through our analysis of intertask interim activities reported in the previous section.

Glucose supplementation. Studies that administered glucose-containing solutions to participants prior to the experiment or in the interim period between self-control tasks were subjected to a meta-analysis. The effect size was calculated as the difference in second task performance for participants assigned to either a group that received a glucose solution or a control group that received a sweet placebo. Larger effect sizes were indicative of better performance on self-control tasks as a result of glucose supplementation.

Results

The literature search identified 83 experimental studies that satisfied inclusion criteria with 198 independent tests of the ego-depletion effect. Effect sizes for the ego-depletion effect and the effect of depletion on additional dependent variables (effort, positive and negative affect, perceived difficulty, subjective fatigue, and self-efficacy) are reported in Appendix B (see the online supplemental materials).[5] The table also includes moderator coding, a precise description of how the effect size was extracted in each study, and details of the methods adopted to measure additional dependent variables. Effect sizes and characteristics of studies included in the analyses of the conservation (anticipate future self-control task, motivation) and training hypotheses of the strength model are provided in Table 1. Analysis of outliers using Grubbs' (1950) statistic identified five cases. Three outliers were detected in the data set for the overall ego-depletion effect, two on the right-hand side of the distribution ($d = 3.02$, Muraven et al., 2008, Study 1; $d = 2.60$, Tyler & Burns, 2009, Study 2, sample 2) and one on the left-hand side ($d = -0.57$, Wright et al., 2007, Study 2, sample 2). These were replaced with their nearest neighboring values, $d = 1.90$ and $d = -0.11$, respectively, and retained in subsequent analyses. In the analyses for additional dependent variables, one outlier was detected for the negative affect variable ($d = 1.40$, Ciarocco et al., 2001, Study 2) and was also set to its closest neighboring value ($d = 0.99$). In the analyses of additional hypotheses, one outlier was identified for the conservation hypothesis, expect future task analysis ($d = 2.61$, Tyler & Burns, 2009) and was replaced with its nearest neighbor ($d = 1.70$).

Overall Ego-Depletion Effect

Results of the meta-analysis of the overall ego-depletion effect are presented in Table 2. The averaged corrected standardized mean difference for ego depletion on self-control dependent measures was $d^{+} = 0.62$, $CI_{95} = [0.57, 0.67]$, $Q(197) = 301.79$, $p < .001$. This represents a medium-to-large effect size (Cohen, 1987). All but two of the effect sizes in the data set were positive in valence. The Q statistic, percentage of variance accounted for by sampling error variance (65.61%), and an I^2 statistic exceeding 25% (34.72%) showed a substantial degree of heterogeneity in the effect size across the studies, which indicated the likelihood of extraneous moderators of the effect (Higgins & Thompson, 2002). The confidence intervals did not include zero, leading to a rejection of the null hypothesis. The fail-safe sample size (N_{FS}) exceeded Rosenberg's (2005) cutoff value, indicating that it was highly unlikely that sufficient studies with null effects would exist to reduce the ego-depletion effect to a trivial value.

Additional Dependent Variables

Average corrected effect size statistics for the effect of ego depletion on other dependent variables are given in Table 2. Each

[5] Five effect sizes were included in the analysis testing the effect of ego depletion on blood glucose. The effect sizes are not reported in Appendix B, as few of the studies involved in the blood glucose analysis were included in the meta-analysis of the overall ego-depletion effect. The effect sizes were from Studies 3 ($d = 1.64$, $n = 16$), 4 ($d = 1.23$, $n = 12$), 5 ($d = 0.96$, $n = 23$), and 6 ($d = 0.89$, $n = 17$) in Gailliot et al.'s (2007) article and Dvorak and Simons' (2009) study ($d = 0.69$, $n = 90$).

Table 1
Characteristics of Studies Used in Meta-Analyses Testing Additional Hypotheses

Hypothesis	Author	Study	*N*	*d*[a]
Conservation				
Future self-control	Muraven, Shmueli, & Burkley (2006)	1	46	0.91
		2	34	1.04[b]
		3	31	0.66[b]
		4	38	0.61[c]
	Tyler & Burns (2009)	1	41	2.53[b]
		2	30	1.70[d]
		3	40	1.00[e]
Motivation	Moller et al. (2006)	1	24	1.05[f]
		2	24	3.75[f]
		3	30	3.84[f]
	Muraven et al. (2008)	1	16	4.59[f]
		2	44	0.65[f]
		3	48	0.78[g]
	Muraven & Slessareva (2003)	1	43	0.60[h]
		2	41	0.92[h]
		3	24	0.89[h]
	Stewart et al. (2009)		42	0.72[i]
Training	Finkel et al. (2009)	5	40	0.82[j]
	Gailliot, Plant, et al. (2007)	1	20	0.99[k]
		2	22	0.91[k]
		4	52	0.50[k]
	Hui et al. (2009)		42	0.48[l]
	Muraven et al. (1999)		69	0.57[k]
	Oaten & Cheng (2006a)		45	8.59[m]
	Oaten & Cheng (2006b)		24	3.13[n]
	Oaten & Cheng (2007)		49	5.97[o]
Glucose supplementation	DeWall et al. (2008)	2	30	0.96[p]
	Gailliot et al. (2007)	8	73	0.55[q]
		9	18	1.57[r]
	Gailliot et al. (2009)		51	0.69[s]
	Masicampo & Baumeister (2008)		57	0.77[t]

[a] Ego-depletion effect from dual-task paradigm for depleted participant group in the presence and absence of moderator (future self-control, motivation, training, and glucose supplementation). [b] Expect future self-control task vs. expect no future self-control task conditions. [c] Expect future self-control task vs. expect future hard task conditions. [d] Average effect size for 3-min and 10-min actual task duration vs. 20-min actual task duration. [e] Experiment finished vs. experiment unfinished conditions. [f] Autonomy vs. controlled motivational conditions. [g] Pressure vs. no pressure conditions. [h] Motivation vs. no motivation condition; motivational manipulations included increasing interest in the final task, highlighting the benefits of practice, and providing monetary incentives. [i] High expectancy of reward vs. low expectancy of reward conditions. [j] Effect size is overall effect of regulation training between self-control exercise vs. control groups; self-control training required participants to engage in either verbal regulation (avoid colloquialisms, slang, abbreviated, and shorthand terms) or physical regulation (use of nondominant hand for everyday tasks) over a period of 2 weeks. [k] Self-control exercise vs. no exercise condition; self-control exercises required modifying speech, modifying posture, controlling emotions, monitoring eating habits, and avoiding use of colloquialisms over a period of 2 weeks. [l] Effect size is average across crossing-out-letter and cold-pressor dependent tasks between the strong training vs. no training groups; self-control exercises required participants to engage in an incongruent Stroop task and rinse their mouth with Listerine for 30 s twice a day over a period of 2 weeks. [m] Self-control exercise (Cohort 1) vs. no exercise (Cohort 2) groups; self-control exercises required participants to engage in a regular program of study including self-imposed deadlines, a study schedule, and use of a study register and diary to enhance self-monitoring over a period of 2 months. [n] Self-control exercise (Cohort 1) vs. no exercise (Cohorts 2 and 3) groups; self-control exercises required participants to engage in a regular tailored program of physical activity prescribed by a gym instructor over a period of 2 months. [o] Self-control exercise (Cohort 1) vs. no exercise (Cohort 2) groups; self-control exercises required participants to engage in a personal financial management program including spending diaries and program logs over a period of 4 months. [p] Effect size is average effect of supplementation (glucose vs. placebo) condition on word fragments task performance for participants in the high depletion (mortality salience) condition. [q] Effect size is average effect of supplementation (glucose vs. placebo) condition on self-reported willingness to help after participants had completed an examination as part of their psychology course. [r] Effect size is average effect of supplementation (glucose vs. placebo) condition on number of voluntary helping hours given for participants in the high depletion (attention control) condition. [s] Effect size is average effect of supplementation (glucose vs. placebo) condition on number of prejudiced statements given for participants high in prejudiced attitudes. [t] Effect size is average effect of supplementation (glucose vs. placebo) condition on choice of apartment (attraction effect) for participants in the high depletion (attention control) condition.

effect represents the standardized mean difference in the target dependent variable for ego-depleted participants and nondepleted controls. Effect sizes for effort, $d^+ = 0.64$, CI_{95} [0.47, 0.80], $Q(30) = 95.04$, $p < .001$, perceived difficulty, $d^+ = 0.94$, CI_{95} [0.73, 1.14], $Q(57) = 456.57$, $p < .001$, subjective fatigue, $d^+ = 0.44$, CI_{95} [0.26, 0.63], $Q(25) = 97.61$, $p < .001$, and blood glucose levels, $d^+ = -0.87$, CI_{95} [−1.20, −0.54], $Q(4) = 2.83$, $p = .59$, were significantly different from zero and were medium to large in magnitude. Effect sizes for positive affect, $d^+ = -0.03$, CI_{95} [−0.12, 0.05], $Q(66) = 146.09$, $p < .01$, negative affect, $d^+ = 0.14$, CI_{95} [0.06, 0.22], $Q(35) = 45.73$, $p = .11$, and self-efficacy, $d^+ = 0.16$, CI_{95} [−0.19, 0.51], $Q(4) = 8.10$, $p = .09$, were substantially smaller. The confidence intervals for the positive affect and self-efficacy effect sizes included the value of

Table 2
Results of Meta-Analysis of Ego Depletion

Effect	*k*	*N*	d^+	d^+ CI_{95} *LL*	d^+ CI_{95} *UL*	*SD*	*SE*	N_{FS}	Var	*Q*	I^2	I^2 CI_{95} *LL*	I^2 CI_{95} *UL*
Overall ego-depletion effect	198	10,782	0.62	0.57	0.67	0.20	0.02	50,445	65.61	301.79***	34.72	22.14	45.27
Other dependent variables													
Effort	31	1,835	0.64	0.47	0.80	0.39	0.09	1,383	32.62	95.04***	69.49	55.69	78.99
Positive affect	67	4,033	−0.03	−0.12	0.05	0.28	0.05	0	45.86	146.09**	54.82	40.48	65.71
Negative affect	36	2,237	0.14	0.06	0.22	0.13	0.04	55	78.72	45.73	23.46	0.00	49.56
Perceived difficulty	58	3,597	0.94	0.73	1.14	0.72	0.10	12,994	12.70	456.57***	87.52	84.62	89.86
Subjective fatigue	26	1,809	0.44	0.26	0.63	0.41	0.09	554	26.64	97.61***	74.39	62.44	82.54
Self-efficacy	5	210	0.16	−0.19	0.51	0.25	0.18	0	61.76	8.10	50.62	0.00	81.88
Blood glucose	5	158	−0.87	−1.20	−0.54	0.00	0.17	28	100.00	2.83	0.00		
Strength model hypotheses													
Conservation hypothesis													
Future self-control	7	260	1.04	0.78	1.30	0.15	0.13	106	83.28	8.41	28.66	0.00	69.31
Motivation	10	336	1.05	0.49	1.61	0.83	0.29	301	17.82	56.12***	83.96	72.08	90.79
Training hypothesis	9	363	1.07	0.10	2.03	1.43	0.49	567	6.48	138.98***	94.24	91.09	96.28
Glucose supplementation	5	229	0.75	0.48	1.03	0.00	0.14	32	100.00	3.36	0.00		

Note. *k* = no. effect sizes in meta-analysis; *N* = total sample size in meta-analysis; d^+ = averaged corrected standardized difference effect size; CI_{95} = 95% confidence intervals; *LL* = lower limit of confidence interval; *UL* = upper limit of confidence interval; *SD* = residual standard deviation of d^+; *SE* = standard error of d^+; N_{FS} = fail-safe *N*; Var = % variance attributed to sampling error variability; *Q* = Cochran's (1952) *Q* statistic; I^2 = Higgins and Thompson's (2002) I^2 statistic.
** $p < .01$. *** $p < .001$.

zero. With the exception of effect sizes for negative affect and blood glucose, all effect sizes exhibited significant heterogeneity.

Moderator Analyses

Averaged corrected standardized-difference effect sizes and associated statistics for each moderator group are provided in Table 3.

Sphere of depleting task. We tested the specific and general spheres of depleting task as moderators of the overall ego-depletion effect. Medium-to-large effect sizes were observed for moderator groups defined according to the specific sphere of depleting task adopted: controlling emotions, $d^+ = 0.62$, CI_{95} [0.50, 0.74], $Q(23) = 33.67$, $p = .07$, thoughts, $d^+ = 0.63$, CI_{95} [0.53, 0.75], $Q(24) = 18.16$, $p = .80$, impulses, $d^+ = 0.55$, CI_{95} [0.46, 0.64], $Q(60) = 128.26$, $p < .001$, and attention, $d^+ = 0.65$, CI_{95} [0.50, 0.81], $Q(20) = 10.68$, $p = .95$; choice and volition, $d^+ = 0.82$, CI_{95} [0.62, 1.00], $Q(11) = 8.87$, $p = .63$; and cognitive, $d^+ = 0.54$, CI_{95} [0.29, 0.80], $Q(12) = 30.64$, $p < .01$, and social, $d^+ = 0.75$, CI_{95} [0.65, 0.84], $Q(37) = 30.69$, $p = .76$, processing tasks. Five of these effects were homogenous. Confidence intervals revealed that the ego-depletion effect size for the controlling impulses task moderator group was significantly smaller than the effect size for the social processing task moderator group. There were no other significant differences. Moderator analysis of experiments adopting affective, $d^+ = 0.57$, CI_{95} [0.49, 0.64], $Q(87) = 163.59$, $p < .001$, cognitive, $d^+ = 0.65$, CI_{95} [0.57, 0.73], $Q(70) = 95.23$, $p < .05$, and combined affective and cognitive, $d^+ = 0.73$, CI_{95} [0.64, 0.83], $Q(38) = 32.56$, $p = .67$, depleting tasks produced effect sizes of similar magnitude. There were no significant differences in effect sizes across the moderator groups. Only the effect size for studies classified as combined affective and cognitive was homogeneous.

Frequently used depleting tasks. We also tested whether the average ego-depletion effect size varied across studies adopting frequently used depleting tasks. Analyses for crossing out letters, $d^+ = 0.77$, CI_{95} [0.65, 0.90], $Q(19) = 25.68$, $p = .14$, Wegner's white-bear paradigm, $d^+ = 0.65$, CI_{95} [0.52, 0.78], $Q(18) = 16.72$, $p = .54$, video-watching affect regulation, $d^+ = 0.55$, CI_{95} [0.42, 0.68], $Q(18) = 18.83$, $p = .40$, and video-watching attention control, $d^+ = 0.61$, CI_{95} [0.48, 0.74], $Q(18) = 23.89$, $p = .16$, tasks revealed medium-to-large average effect sizes for these tasks with no significant differences across moderator groups. The effect size for the modified Stroop task was smaller in magnitude, $d^+ = 0.40$, CI_{95} [0.26, 0.55], $Q(12) = 23.01$, $p < .05$, and significantly smaller than the effect size for the crossing-out-letters task. With the exception of the Stroop task group, all of the moderator analyses yielded homogeneous effect sizes.[6]

Duration of depleting task. Depleting task duration in minutes was treated as a continuous moderator of the ego-depletion effect. The majority of studies ($k = 148$) reported task duration data, and this was converted into minutes. We conducted a linear regression analysis, with the ego-depletion effect size as the

[6] The modified Stroop task was the only specific self-control depleting task that exhibited significant heterogeneity and a mean effect size significantly lower than those in the other depleting task moderator groups. This pattern mirrored the pattern of effect sizes for tasks in the controlling impulse and affective groups in the spheres of depleting task moderator analysis. We therefore tested whether studies adopting the Stroop task were responsible for the heterogeneity and significantly lower averaged effect sizes observed in these spheres by omitting studies adopting the Stroop task ($k = 13$) from the controlling impulse and affective moderator analyses. Reestimating the meta-analysis revealed that omitting these tasks did not lead to a substantive change in the averaged effect size or an appreciable narrowing of the confidence intervals for the controlling impulses sphere, $d^+ = 0.62$, CI_{95} [0.51, 0.74], $Q(47) = 95.16$, $p < .001$, or the affective sphere, $d^+ = 0.62$, CI_{95} [0.54, 0.70], $Q(74) = 129.47$, $p < .001$, of the depleting task. The substantial heterogeneity remained.

Table 3
Results of Moderator Analyses

Moderator	*k*	*N*	d^+	d^+ CI_{95} *LL*	d^+ CI_{95} *UL*	*SD*	*SE*	N_{FS}	Var	*Q*	I^2	I^2 CI_{95} *LL*	I^2 CI_{95} *UL*
Sphere of depleting task													
Specific task classification[a]													
Controlling emotions	24	1,146	0.62	0.50	0.74	0.19	0.06	636	71.28	33.67	34.69	0.00	58.51
Controlling thoughts	25	1,212	0.63	0.53	0.75	0.00	0.06	708	100.00	18.16	0.00		
Controlling impulses	61	3,956	0.55	0.46	0.64	0.27	0.05	4,434	47.56	128.26***	53.22	37.39	65.05
Controlling attention	21	1,078	0.65	0.50	0.81	0.22	0.08	569	63.80	10.68	0.00		
Choice and volition	12	475	0.82	0.62	1.00	0.00	0.10	213	100.00	8.87	0.00		
Cognitive processing	13	615	0.54	0.29	0.80	0.35	0.13	136	42.42	30.64**	60.84	28.21	78.63
Social processing	38	1,966	0.75	0.65	0.84	0.00	0.05	1,471	100.00	30.69	0.00		
Global classification[b]													
Affective	88	5,351	0.57	0.49	0.64	0.24	0.04	9,086	53.79	163.59***	46.82	31.66	58.61
Cognitive	71	3,380	0.65	0.57	0.73	0.18	0.04	6,237	74.56	95.23*	26.49	0.78	45.55
Affective and cognitive	39	2,051	0.73	0.64	0.83	0.00	0.05	2,512	100.00	32.56	0.00		
Frequently used depleting tasks													
Crossing out letters	20	1,101	0.77	0.65	0.90	0.15	0.06	760	77.88	25.68	26.01	0.00	57.09
White bear paradigm	19	932	0.65	0.52	0.78	0.00	0.07	432	100.00	16.72	0.00		
Video-watching affect regulation[c]	19	963	0.55	0.42	0.68	0.00	0.07	315	100.00	18.83	0.00		
Video-watching attention control[d]	19	1,006	0.61	0.48	0.74	0.14	0.06	411	79.54	23.89	24.65	0.00	56.83
Modified Stroop	13	1,322	0.40	0.26	0.55	0.18	0.07	160	56.50	23.01*	47.85	72.55	0.91
Interim period													
Completed questionnaires	119	5,726	0.71	0.65	0.77	0.18	0.03	20,948	73.47	161.96**	27.14	8.06	42.26
Filler task and/or break between tasks	24	1,115	0.72	0.60	0.85	0.00	0.06	6,662	100.00	22.30	0.00		
No interim period reported	55	3,941	0.47	0.39	0.55	0.17	0.04	2,876	66.11	83.19**	35.08	9.57	53.40
Experiment presentation													
Presented as single experiment	134	7,413	0.58	0.53	0.64	0.19	0.03	20,455	68.40	195.91***	32.11	15.75	45.30
Presented as separate experiment	64	3,369	0.71	0.63	0.80	0.21	0.04	6,627	66.12	96.80***	34.92	11.45	52.17
Administered by same experimenter	183	10,133	0.61	0.56	0.66	0.21	0.03	41,876	64.54	283.55***	35.81	22.96	46.52
Administered by different experimenters	15	649	0.86	0.69	1.01	0.00	0.07	404	100.00	9.76	0.00		
Sphere of dependent task													
Specific classification[e]													
Controlling impulses	104	4,836	0.71	0.64	0.78	0.21	0.03	15,427	68.84	151.07**	31.82	12.89	46.63
Choice and volition	8	1,300	0.22	0.11	0.33	0.00	0.06	23	100.00	4.19	0.00		
Cognitive processing	47	2,505	0.60	0.52	0.67	0.00	0.04	2,470	100.00	43.03	0.00		
Social processing	33	1,934	0.69	0.60	0.78	0.00	0.05	1,797	100.00	29.11	0.00		
Global classification													
Affective	107	4,945	0.71	0.64	0.78	0.21	0.04	16,366	68.72	155.70**	31.92	13.33	46.53
Cognitive	58	3,903	0.48	0.40	0.55	0.17	0.04	3,106	67.66	85.73**	33.51	8.01	51.94
Affective and cognitive	33	1,934	0.69	0.60	0.78	0.00	0.05	1,797	100.00	29.11	0.00		
Frequently used dependent tasks													
Handgrip	18	872	0.64	0.45	0.83	0.28	0.10	407	53.18	33.85**	49.78	13.52	70.84
Modified Stroop	15	633	0.76	0.59	0.94	0.16	0.09	306	80.88	18.55	24.53	0.00	59.25
Food taste test	10	527	0.50	0.33	0.68	0.16	0.09	71	75.71	13.21	31.87	0.00	67.48
Math or mental arithmetic	10	447	0.50	0.31	0.69	0.00	0.10	55	100.00	7.80	0.00		
Solvable anagram	10	670	0.60	0.44	0.76	0.08	0.08	128	91.43	10.94	17.73	0.00	58.74
Matched depleting and dependent tasks													
Specific classification													
Matched	40	1,881	0.59	0.48	0.71	0.23	0.06	1,565	63.60	62.90**	38.00	8.99	57.76
Unmatched	158	8,901	0.63	0.58	0.68	0.20	0.03	33,925	66.25	238.49***	34.17	19.79	45.97
Global classification													
Matched	68	3,226	0.61	0.52	0.70	0.21	0.04	5,067	67.92	100.12**	33.08	9.60	50.46
Unmatched	130	7,556	0.63	0.57	0.69	0.20	0.03	23,300	64.51	201.52***	35.99	20.54	48.43

(*table continues*)

Table 3 (*continued*)

Moderator	*k*	*N*	d^+	d^+ CI_{95} *LL*	d^+ CI_{95} *UL*	*SD*	*SE*	N_{FS}	Var	*Q*	I^2	I^2 CI_{95} *LL*	I^2 CI_{95} *UL*
Type of dependent task													
Behavioral self-control measure	170	9,096	0.62	0.56	0.67	0.22	0.03	35,689	61.91	274.61***	38.46	25.77	48.97
Nonbehavioral judgment measure	28	1,686	0.66	0.56	0.76	0.00	0.05	1,231	100.00	26.44	0.00		
Control condition task[f]													
Easier version	170	9,272	0.62	0.56	0.67	0.23	0.03	36,526	60.03	283.19***	40.32	28.13	50.44
Individual difference	21	1,194	0.66	0.54	0.78	0.00	0.06	618	100.00	11.37	0.00		
Alternative	5	274	0.53	0.29	0.77	0.00	0.12	16	100.00	0.23	0.00		
Task complexity													
Complex	27	1,495	0.65	0.54	0.75	0.00	0.05	972	100.00	26.44	0.00		
Simple	9	407	0.35	0.15	0.55	0.00	0.10	16	100.00	5.93	0.00		
Source laboratory													
Baumeister	98	5,906	0.60	0.53	0.66	0.21	0.03	12,425	61.99	158.08***	38.64	21.51	52.02
Other	100	4,876	0.66	0.59	0.72	0.19	0.04	12,758	70.71	141.43**	30.00	10.01	45.55

Note. *k* = no. effect sizes in meta-analysis; *N* = total sample size in meta-analysis; d^+ = averaged corrected standardized difference effect size; CI_{95} = 95% confidence intervals; *LL* = lower limit of confidence interval; *UL* = upper limit of confidence interval; *SD* = residual standard deviation of d^+; *SE* = standard error of d^+; N_{FS} = fail-safe *N*; Var = % variance attributed to sampling error variability; *Q* = Cochran's (1952) *Q* statistic; I^2 = Higgins and Thompson's (2002) I^2 statistic.

[a] Two studies ($k = 4$) were omitted from the specific classification analysis because two depleting self-control tasks in different spheres were used concurrently (Fischer et al., 2007, Studies 1, 2, and 4; Ostafin, Marlatt, & Greenwald, 2008). [b] The studies that used depleting tasks in two spheres were classified into the affective (Fischer et al., 2007, Studies 1, 2, and 4) or combined affective and cognitive (Ostafin et al., 2008) moderator groups for the global classification analysis. [c] One study ($k = 3$) was omitted from this analysis because the emotion regulation tasks were used in conjunction with tasks in another sphere (Fischer et al., 2007, Studies 1, 2, and 4). [d] One study ($k = 3$) was omitted from this analysis because the attention control task was used in conjunction with a task in another sphere (Fischer et al., 2007, Studies 1, 2, and 4). [e] Three moderator groups had four or fewer effect sizes and were deemed unsuitable to be included in the analysis: controlling emotions ($k = 3$; Muraven et al., 1998, Study 3; Schmeichel, 2007, Study 3; Vohs et al., 2005, Study 3), controlling attention ($k = 3$; Muraven et al., 2008, Studies 1 and 3; Muraven, Shmueli, & Burkley, 2006, Study 2), and controlling thoughts ($k = 0$). [f] Only two effect sizes were available for the moderator group in which participants allocated to the control condition did not engage in any task (Baumeister et al., 1998, Study 2; Burkley, 2008, Study 2), so this moderator group was omitted from the analysis.

* $p < .05$. ** $p < .01$. *** $p < .001$.

dependent variable and task duration as an independent predictor, weighted by the inverse variance of each effect size (Hedges & Olkin, 1983; Sánchez-Meca & Marín-Martínez, 1998). The analysis yielded a marginally significant effect for task duration on ego depletion, but the effect size was small ($\beta = .11$, $z = 1.79$, $p = .07$).

Interim period. We conducted an analysis examining the effect of the type of interim activity on ego depletion in the dual-task paradigm. The averaged effect size did not vary across moderator groups for studies in which participants completed questionnaires during the interim period, $d^+ = 0.71$, CI_{95} [0.65, 0.77], $Q(118) = 161.96$, $p < .01$, or completed a filler task or had a break between the tasks, $d^+ = 0.72$, CI_{95} [0.60, 0.85], $Q(23) = 22.30$, $p = .50$, but the effect for studies that reported no interim period was significantly smaller, $d^+ = 0.47$, CI_{95} [0.39, 0.55], $Q(54) = 83.19$, $p < .01$. The analysis for the filler task or break group was homogeneous, but the remaining effects exhibited substantial heterogeneity.

Experiment presentation. The ego-depletion effect for studies presenting the two tasks as single experiments, $d^+ = 0.58$, CI_{95} [0.53, 0.64], $Q(133) = 195.91$, $p < .001$, or separate experiments, $d^+ = 0.71$, CI_{95} [0.63, 0.80], $Q(63) = 96.80$, $p < .001$, were not significantly different. However, the effect size for tasks administered by the same experimenter, $d^+ = 0.61$, CI_{95} [0.56, 0.66], $Q(182) = 283.55$, $p < .001$, was significantly smaller than that for tasks administered by a different experimenter, $d^+ = 0.86$, CI_{95} [0.69, 1.01], $Q(14) = 9.76$, $p = .78$. Effect sizes were medium to large in all cases, and all effects with the exception of the effect for tasks administered by different experimenters exhibited substantial heterogeneity.

Sphere of dependent task. We tested whether groups of effect sizes defined according to the specific features of the criterion self-control tasks would moderate the ego-depletion effect. Three of the moderator groups (controlling attention, controlling emotions, and controlling thoughts) contained fewer than five effect sizes and were deemed insufficient for meta-analytic synthesis. Analyses of the four remaining moderator groups revealed no significant differences in effect sizes for tasks in the controlling impulses sphere, $d^+ = 0.71$, CI_{95} [0.64, 0.78], $Q(103) = 151.07$, $p < .01$, cognitive processing sphere, $d^+ = 0.60$, CI_{95} [0.52, 0.67], $Q(46) = 43.03$, $p = .60$, and social processing sphere, $d^+ = 0.69$, CI_{95} [0.60, 0.79], $Q(32) = 29.11$, $p = .61$. However, confidence intervals indicated that the ego-depletion effect was significantly smaller in experiments adopting choice and volition tasks, $d^+ = 0.22$, CI_{95} [0.11, 0.33], $Q(7) = 4.19$, $p = .76$, than in all other groups. All of the effect sizes were homogeneous, with the exception of the effect in the controlling impulses tasks group. For the moderator analysis in which dependent self-control tasks were classified in accordance with their global features, effect sizes for affective tasks, $d^+ = 0.71$, CI_{95} [0.64, 0.78], $Q(106) = 155.70$, $p < .01$, and combined affective and cognitive tasks, $d^+ = 0.69$, CI_{95} [0.60, 0.79], $Q(32) = 29.11$, $p = .61$, were significantly larger relative to the effect for cognitive tasks, $d^+ = 0.48$, CI_{95} [0.40, 0.55], $Q(57) = 85.73$, $p < .01$. Only the effect size for the combined affective and cognitive group was homogeneous.

Frequently used dependent tasks. Five dependent self-control tasks were used on 10 or more occasions. Averaged effect sizes for handgrip, $d^+ = 0.64$, CI_{95} [0.45, 0.83], $Q(17) = 33.85$, $p < .01$, modified Stroop, $d^+ = 0.76$, CI_{95} [0.59, 0.94], $Q(14) = 18.55$, $p = .18$, food taste test, $d^+ = 0.50$, CI_{95} [0.33, 0.68], $Q(9) = 13.21$, $p = .20$, math or mental arithmetic, $d^+ = 0.50$, CI_{95} = [0.31, 0.69], $Q(9) = 7.80$, $p = .55$, and solvable anagram, $d^+ = 0.60$, CI_{95} [0.44, 0.76], $Q(9) = 10.94$, $p = .28$, were medium to large in size and were not significantly different across tasks. With the exception of the handgrip task, all of the moderator analyses resulted in homogeneous effect sizes.

Matched depleting and dependent tasks. The ego-depletion effect size for studies that adopted depleting and dependent tasks that were matched on task sphere, specific classification, $d^+ = 0.59$, CI_{95} [0.48, 0.71], $Q(39) = 62.90$, $p < .01$; global classification, $d^+ = 0.61$, CI_{95} [0.52, 0.70], $Q(67) = 100.12$, $p < .001$, did not differ from the effect size for studies adopting tasks unmatched on sphere: specific classification, $d^+ = 0.63$, CI_{95} [0.58, 0.68], $Q(157) = 238.49$, $p < .001$; global classification, $d^+ = 0.63$, CI_{95} [0.57, 0.69], $Q(129) = 201.52$, $p < .001$.[7] Only the moderator group in which the tasks were matched according to specific sphere classification was homogeneous.

Type of dependent task. Tests of the ego-depletion effect for studies employing a behavioral dependent measure, $d^+ = 0.62$, CI_{95} [0.56, 0.67], $Q(169) = 274.61$, $p < .001$, or a nonbehavioral or judgment dependent measure, $d^+ = 0.66$, CI_{95} [0.56, 0.76], $Q(27) = 26.44$, $p = .49$, revealed medium-to-large effect sizes in each moderator group with no significant differences. The effect size for behavioral measures exhibited substantial heterogeneity, but the effect size for nonbehavioral or judgment measures was homogeneous.

Control condition task. Meta-analyses of studies using an easier version of the depleting task, $d^+ = 0.62$, CI_{95} [0.56, 0.67], $Q(169) = 283.19$, $p < .001$, an alternative task, $d^+ = 0.53$, CI_{95} [0.29, 0.77], $Q(4) = 0.23$, $p = .99$, and the same task with an individual difference characteristic to evoke depletion, $d^+ = 0.66$, CI_{95} [0.54, 0.78], $Q(20) = 11.37$, $p = .94$, revealed no differences in effect size. The effect size for studies using an easy version of the depleting task exhibited substantial heterogeneity, but the effect sizes for the alternative task and same task with individual differences groups were homogeneous.

Task complexity. Ego-depletion effect sizes were larger for the subset of studies adopting complex dependent tasks, $d^+ = 0.65$, CI_{95} [0.54, 0.75], $Q(26) = 26.44$, $p = .44$, than for those adopting less complex or simple tasks, $d^+ = 0.35$, CI_{95} [0.15, 0.55], $Q(8) = 5.93$, $p = .66$, a difference that was borderline significant. In both cases, the averaged effect size was homogeneous.

Source laboratory. There were no significant differences in the average effect size for studies originating from the labs of Baumeister and collaborators, $d^+ = 0.60$, CI_{95} [0.53, 0.66], $Q(97) = 158.08$, $p < .001$, and from other laboratories, $d^+ = 0.66$, CI_{95} [0.59, 0.72], $Q(99) = 141.43$, $p < .01$. Both effects exhibited substantial heterogeneity.

Individual differences. Several studies ($k = 9$) measured trait self-control concurrent with ego depletion in dual-task paradigm experiments (DeWall et al., 2007, Study 4; Dvorak & Simons, 2009; Finkel & Campbell, 2001, Study 2; Gailliot & Baumeister, 2007b, Studies 1 and 2; Gailliot, Schmeichel, & Maner, 2007, Studies 1 & 2; Muraven, Pogarsky, & Shmueli, 2006; Stillman et al., 2009, Study 2). However, the studies did not provide sufficient data to test individual differences in self-control as a moderator of the ego-depletion effect in our meta-analysis. In particular, effect size data for the ego-depletion effect in high and low trait self-control groups were not available. No other individual difference or personality constructs were measured with sufficient regularity to offer a cumulative analysis of their effects on ego depletion.

Relations between moderators. Pairwise tests of relations between significant moderator variables are presented in Appendix C (see online supplemental materials). The variables included in the analysis were sphere of depleting task (specific classification), frequently used depleting task, experiment presentation (same vs. different experimenters), interim period, sphere of depleting task (specific and global classifications), and task complexity. The analysis yielded relatively few significant relations among the variables, suggesting that our selection of moderators and coding procedures were largely effective in identifying unique moderator variables that were not confounded with others (Lipsey, 2003).

There were significant associations between sphere of depleting task (specific classification) and frequently used depleting task moderator variables, $\chi^2(12) = 270.00$, $p < .001$, and between sphere of dependent task, specific and global classifications, $\chi^2(10) = 396.00$, $p < .001$. These findings were unsurprising, as the variables involved represented nested versions of the same analysis according to our moderator coding. For example, the sphere of dependent task moderator variables, classified according to specific and global features, were strongly associated because specific domains of depleting task (e.g., controlling impulses or controlling emotions) were exclusive to categories of depleting tasks in the global domain (e.g., affective tasks). Conducting follow-up analyses on the basis of these relations was not warranted, as such analyses would fail to explain additional variance in the ego-depletion effect across moderator groups.

We found significant relations between the interim period and sphere of depleting task (specific classification) moderators, $\chi^2(12) = 36.39$, $p < .001$. Examination of the classification tables identified that the relationship was due to a disproportionate number of cases in the "no interim reported" category that adopted social processing and controlling impulses tasks relative to the other categories. As our moderator analysis revealed that studies adopting no interim period between tasks exhibited a significantly smaller ego-depletion effect than studies that included an interim period/filler task or had participants complete questionnaires, we conducted follow-up analyses to investigate whether task sphere explained this variance. We conducted separate meta-analyses in

[7] We also examined relations among the specific and global task sphere and frequently used tasks moderator variables across depleting and dependent task types. This was to evaluate whether there was a tendency for experimenters to adopt tasks from the same sphere for the depleting and dependent tasks in the dual-task paradigm. We found no association for any combination of these variables pointing to the independence of these moderators. This was consistent with the null finding in the moderator analysis, in which depleting and dependent tasks were coded as matched on task sphere. Taken together, these results indicate that experimenters in the present sample of studies tended to adopt depleting and dependent tasks from different spheres of self-control and demonstrate their utility in testing the generality of the ego-depletion effect.

moderator groups defined by depleting task sphere (social processing vs. controlling impulses vs. other spheres) and interim period (interim period/filler task/completed questionnaires vs. no interim reported). Results indicated that the ego-depletion effect was significantly larger in several moderator groups—social processing tasks–interim period, $d^+ = 0.79$, CI_{95} [0.68, 0.92], $Q(23) = 19.51$, $p < .67$, social processing tasks–no interim reported, $d^+ = 0.68$, CI_{95} [0.54, 0.82], $Q(13) = 9.71$, $p = .72$, controlling impulses–interim period, $d^+ = 0.67$, CI_{95} [0.56, 0.78], $Q(45) = 77.40$, $p < .01$, and other spheres–interim period, $d^+ = 0.71$, CI_{95} [0.63, 0.78], $Q(70) = 73.30$, $p = .37$—relative to the effect in the tasks from the controlling impulses–no interim reported moderator group, $d^+ = 0.37$, CI_{95} [0.23, 0.52], $Q(14) = 30.53$, $p < .01$. Furthermore, the effect size in the other studies–no interim reported moderator group, $d^+ = 0.49$, CI_{95} [0.34, 0.65], $Q(23) = 46.48$, $p < .01$, exhibited significant overlap in confidence intervals with effect sizes in the other moderator groups, with the exception of the social processing tasks–interim period group. These results suggest that the inclusion of studies adopting controlling impulses depleting tasks led to the significant attenuation of the ego-depletion effect in the no interim reported moderator group. However, as the confidence intervals for the other studies–no interim reported moderator group straddled those of the controlling impulses–no interim reported moderator group and those from other moderator groups, it is likely that the association among these moderators did not fully account for the variation in the ego-depletion effect size due to interim period.

The presentation of tasks by the same or different experimenters significantly moderated the ego-depletion effect. This moderator variable was also significantly related to sphere of depleting task (specific classification), $\chi^2(6) = 20.40$, $p < .01$. We therefore investigated whether depleting task sphere confounded this effect. An examination of the classification tables for these variables revealed that a disproportionately larger proportion of studies adopting depleting tasks in the social processing sphere also used different experimenters. For many of the studies adopting depleting tasks in the social processing sphere, the use of different experimenters was an integral part of the depletion paradigm (e.g., experiments requiring an interracial interaction; Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Richeson et al., 2005; Trawalter & Richeson, 2006). A follow-up moderator analysis by depleting task sphere (social processing vs. other spheres) and experiment presentation (same vs. different experimenters) revealed that studies adopting depleting tasks in the social processing sphere and used different experimenters exhibited a larger ego-depletion effect, $d^+ = 1.00$, CI_{95} [0.75, 1.24], $Q(7) = 3.93$, $p = .79$, than studies adopting social processing tasks and using the same experimenter, $d^+ = 0.71$, CI_{95} [0.60, 0.80], $Q(29) = 22.08$, $p = .82$. Similarly, studies adopting tasks from other spheres and using different experimenters exhibited a larger ego-depletion effect, $d^+ = 0.76$, CI_{95} [0.56, 0.97], $Q(6) = 6.09$, $p = .41$, than studies adopting tasks from other spheres and using the same experimenter, $d^+ = 0.59$, CI_{95} [0.53, 0.65], $Q(148) = 253.18$, $p < .001$. The ego-depletion effect was significantly larger in the social processing tasks– different experimenter moderator group than in the other tasks–same experimenter moderator group. However, within the spheres of task moderator groups, there were no significant differences in the effect sizes, and the same pattern of findings to the main moderator analysis for experiment presentation was observed.

Testing Strength-Model Hypotheses

Averaged corrected standardized-difference effect sizes and associated statistics for the meta-analyses of additional strength model hypotheses are provided in Table 2.

Conservation. We meta-analyzed studies in which participants were informed they were required to engage in a third self-control task after the second task in the dual-task paradigm. Two studies were included in the analysis with seven separate tests of the effect (Muraven, Shmueli, & Burkley, 2006; Tyler & Burns, 2009). The effect size was large, significant, and homogeneous, $d^+ = 1.04$, CI_{95} [0.78, 1.30], $Q(6) = 8.41$, $p = .21$, such that expecting future self-control performance led to higher levels of ego depletion among depleted samples.

We also tested the moderation of the ego-depletion effect by motivational strategies. Three studies were included in the analysis offering 10 independent tests of the effect (Moller et al., 2006; Muraven et al., 2008; Muraven & Slessareva, 2003). The analysis produced a large effect size, $d^+ = 1.05$, CI_{95} [0.49, 1.61], $Q(9) = 56.12$, $p < .001$, supporting the hypothesis that introducing motivational strategies results in better performance on dependent self-control tasks among ego-depleted people. The effect exhibited significant heterogeneity.

Training. Seven studies provided nine tests of the training hypothesis (Finkel et al., 2009; Gailliot, Plant, et al., 2007; Hui et al., 2009; Muraven et al., 1999; Oaten & Cheng, 2006a, 2006b, 2007). The effect size was large and significant, indicating that participants receiving training performed better on the self-control task and were less ego-depleted than untrained participants, $d^+ = 1.07$, CI_{95} [0.10, 2.03], $Q(8) = 138.98$, $p < .001$. It is important to note that none of the individual effects included in the analysis were small or negative in valence, and the high degree of heterogeneity in the effect reflected the very large range in effect sizes ($d = 0.10$ to 8.59).

Glucose supplementation. We tested the effect of administering glucose (as opposed to placebo) on the ego-depletion effect. Four studies reporting five separate effect sizes were included in the analysis (DeWall et al., 2008; Gailliot, Baumeister, et al., 2007; Gailliot et al., 2009; Masicampo & Baumeister, 2008). Study characteristics are reported in Table 1. Results revealed a large homogeneous effect size, $d^+ = 0.75$, CI_{95} [0.48, 1.03], $Q(4) = 3.36$, $p = .50$, indicating that supplementing people with glucose is associated with significantly better performance on self-control tasks among depleted people relative to controls provided with a sweet placebo.

Discussion

Our main aim in the present study was to conduct a meta-analytic synthesis of the ego-depletion effect in experimental studies adopting the dual-task paradigm. Additional aims were to test (a) the effect of ego depletion on other dependent variables (effort, perceived difficulty, subjective fatigue, negative and positive affect, self-efficacy, and blood glucose), (b) the effect of theoretically-salient moderators on ego depletion, (c) alternative explanations for the ego-depletion effect, and (d) key additional

hypotheses derived from the strength model of self-control. A literature search identified 83 studies that met inclusion criteria and provided 198 independent tests of the ego-depletion effect. The meta-analysis of the overall ego-depletion effect produced a medium-to-large average effect size. The effect was significantly different from zero but displayed substantial heterogeneity. Significant effects were found for ego depletion on effort, perceived difficulty, negative affect, subjective fatigue, and blood glucose, reflecting the effortful, aversive nature of self-control tasks. The effect of ego depletion on positive affect and self-efficacy was trivial and nonsignificant. Moderator analyses revealed that the ego-depletion effect was generally consistent across sphere of depleting and dependent task. The effect size for depleting tasks in the controlling impulses sphere and for the modified Stroop task was smaller relative to a minority of other spheres and tasks. The effect was significantly smaller for studies adopting dependent tasks in the cognitive and choice and volition spheres. The effect was also smaller for simple as opposed to complex dependent tasks, a difference that was borderline significant; for tasks administered by the same experimenter compared to those administered by different experimenters; and for studies that reported no intertask interim period. Presentation of the tasks as separate experiments, whether or not depleting and dependent tasks were matched on sphere, use of behavioral or nonbehavioral dependent measures, type of control condition, and source laboratory, did not moderate the effect. Tests of the additional hypotheses of the strength model revealed that motivational incentives, training on self-control tasks, and glucose supplementation resulted in significantly superior second task performance relative to that of controls among ego-depleted groups. In contrast, participants who anticipated a future self-control task exhibited a significantly larger ego-depletion effect than participants who did not expect a future task in ego-depleted groups.

Implications for the Strength Model

The significant overall effect for the ego-depletion effect provides confirmatory evidence for the acute decrements in self-control task performance observed in experiments adopting the strength model and the dual-task paradigm. Moderator analyses examining the effect for both depleting and dependent tasks in different spheres of self-control also supported the presence of the effect. As predicted, any variation in the effect across spheres was due to differences in the magnitude rather than whether the effect was present or absent. Furthermore, the effect did not vary across studies in which the depleting or dependent tasks were from identical or different spheres of self-control, providing further evidence to support the generality of the effect. Findings are consistent with a resource depletion model, which predicts that performance decrements carry across different spheres of self-control. It also corroborates the view that self-control draws from a single, global resource and depletion is not an artifact of specific spheres or tasks. The present synthesis therefore contributes to knowledge by demonstrating that the ego-depletion effect exists, its associated confidence intervals do not include trivial values, and it is generalizable across spheres of self-control.

The analysis of sphere of task as a moderator provided important information on whether certain spheres of ego-depleting task were more demanding of self-control resources than others. Introducing sphere as a moderator was effective in resolving some of the heterogeneity in the overall ego-depletion effect in some moderator groups. The majority of the spheres exhibited homogeneous ego-depletion effects and did not differ significantly from each other. The general pattern of these results suggests that most tasks are equally taxing of self-control resources. However, there were some variations. Studies that adopted depleting tasks in the controlling impulses sphere and dependent tasks in the cognitive sphere exhibited smaller ego-depletion effect sizes than those in a minority of other spheres. These moderator groups also exhibited high levels of heterogeneity. In some cases, the heterogeneity associated with the effects in these spheres was resolved when moderator groups were formed from individual, frequently used depleting (e.g., crossing out letters) and dependent (e.g., modified Stroop, food taste test) controlling-impulses tasks. Some individual tasks also displayed significant heterogeneity and lower ego-depletion effects (e.g., modified Stroop as a depleting task), but excluding studies adopting this task in the moderator analyses for task sphere (e.g., controlling impulses, affective) did not produce homogeneous effects. The lower size and heterogeneity of the effect in these spheres do not appear to be attributable to one particular task.

Studies adopting choice and volition tasks as a dependent variable exhibited much lower levels of depletion than studies using tasks in other specific spheres of self-control. A possible reason for this variation is that making choices may not place as many demands on depleted individuals' self-control resources as do tasks in other spheres, but this does not appear to be the case when such tasks are used as depleting tasks. On closer inspection, the effect was based on a small sample, with the majority of effects derived from studies using a particular type of consumer-choice task (Masicampo & Baumeister, 2008; Pocheptsova, Amir, Dhar, & Baumeister, 2009). These tasks focus on ego-depleted individuals' failure to select a compromise option in a buying scenario, likely due to the use of simple rather than deep-level processing. The strength of the effect may be reduced for these tasks, because a substantial proportion of people are still able make correct decisions even when depleted. This individual task may therefore be one that is less effective in measuring self-control resource depletion, but it appears to be an exception rather than the rule.

An inconsistency in the ego-depletion literature is whether the ego-depletion effect is exclusively the result of engaging in tasks that require suppressing impulses or overriding dominant responses or whether difficult or challenging tasks also have the propensity to evoke ego depletion. We hypothesized that difficult tasks vary in complexity and, therefore, the extent to which they deplete self-control resources. Although classifying such tasks according to their complexity proved challenging due to their diversity, cognitive processing tasks that varied in the number of processes required provided an opportunity to test the effect of task complexity on ego depletion. Complex tasks required a greater number of cognitive processes such as mixed-arithmetic operations or memory updating than did tasks such as rote memory (Schmeichel, 2007), which required relatively few. Consistent with expectations, dependent tasks classified as complex led to a larger ego-depletion effect than tasks classified as simple. Although the difference was borderline significant, these results provide preliminary evidence that the degree of ego depletion evoked by cognitive processing tasks is dependent on task complexity. Findings

indicate that the depletion of self-control resources is not exclusively confined to tasks that require overriding impulses or habitual responses but also applies to difficult or challenging tasks that demand complex cognitive processing.

It was also important to test whether the type of control condition task with which the depleting self-control task was compared affected the ego-depletion effect. We tested this by including the type of control condition task used in dual-task paradigm experiments as a moderator variable. Most experiments used a modified, easier version of the depleting self-control task for the control condition task (e.g., a congruent Stroop task or eating a tempting food in an ostensible taste test). A common feature of these tasks is that individuals are required to act in accordance with, rather than override, habitual or dominant responses. However, some experiments used individual differences and alternative tasks (e.g., math problems) as the control condition. The average ego-depletion effect in the present meta-analysis did not differ with the type of control condition adopted. Although the selection of an appropriate control condition is an important feature of the dual-task paradigm in order to effectively induce ego depletion, the extent of resource depletion does not depend on the types of control task identified in this analysis. The implication of these findings is that there is some flexibility within the dual-task paradigm in terms of the means to deplete resources as well as the control conditions with which the depleting task is compared. However, researchers must exercise caution when selecting tasks so that the features that define them as depleting or nondepleting are clearly identifiable and can be justified theoretically. Our classification of tasks based on complexity of the processing required may provide a useful guide in this regard.

Another feature of depleting self-control tasks likely to affect ego depletion is the length of time spent on the task. It was proposed, consistent with the conceptualization of self-control as a limited resource, that spending longer on the initial self-control task in the dual-task paradigm would consume more of the resource. Our meta-analysis revealed a marginally significant relationship between duration of depleting task and ego depletion in the hypothesized direction. The small effect size indicates that task duration accounted for relatively little variance in the ego-depletion effect. Task duration should therefore be a minor consideration when designing and evaluating ego-depletion experiments. It is important to note that the task duration range of the studies used in the present analysis was relatively narrow; many of the tasks were relatively brief in duration. This is consistent with the heavy focus on short-term self-control failure in experimental tests of ego depletion. The relatively brief task duration means that it was unlikely there would be an observable deterioration in performance on the initial self-control task itself in these studies. The identification of a decline in performance on the initial task would be a useful additional index of resource depletion and would be consistent with the long-term task performance decrements observed in the mental fatigue and vigilance literature (Parasuraman, 1979; See et al., 1995). Furthermore, no study has manipulated initial task duration in a dual-task paradigm and examined its effects on performance of both initial and second tasks. The present analysis provides the impetus for future research to examine extended task duration as a moderator of ego depletion.

We conducted analyses to test relations between significant moderator variables in order to provide a critical evaluation of potential confounding effects due to interrelationships among moderators. In general, our analysis revealed few significant relations providing evidence that the moderators identified were unique and the analyses were not confounded. We found two instances in which a relationship between moderators had a demonstrable effect on the moderator analyses. We found that experiments that did not report an interim period between tasks exhibited weaker ego-depletion effects than those that reported an interim period or the completion of questionnaires between tasks. This finding was contrary to the recovery hypothesis, which suggests that an interim period between tasks would permit partial recovery of self-control resources and lead to better performance on the second task. Our analysis of relations between moderators suggested that this effect may have been confounded by a significant relationship between the interim period and task sphere moderators. The analysis revealed that the inclusion of studies adopting depleting tasks in the controlling impulses sphere that did not report an interim period may have biased the ego-depletion effect size downward. Reasons why researchers controlling impulses depleting tasks were less likely to report an interim period are unclear and cannot be ascertained from the current analysis. However, there was evidence that this did not account for all the variation in the ego-depletion effect across the interim period. An important consideration when interpreting these findings is that our coding of the "no interim period reported" category for this moderator was relatively crude. For example, it was possible that studies coded as reporting no interim period may have included an interim period or filler task between tasks in their experiment but the authors failed to mention doing so. Full reporting of the duration and experimental requirements (e.g., filler tasks, questionnaire completion) between tasks is advocated to provide more robust data for evaluating whether intertask period moderates the ego-depletion effect.

We also found that presenting tasks in the dual-task paradigm by the same or different experimenters moderated the ego-depletion effect. Contrary to predictions and the experimenter-demand account, the ego-depletion effect size was larger among studies in which the tasks were administered by different experimenters. Analysis of relations between moderator variables suggested that a significant association between the experiment presentation and sphere of depleting task moderators may have confounded the effect. We found that studies adopting social processing depleting tasks were more likely to use different experimenters than studies adopting tasks in other spheres. Our analysis revealed that inclusion of studies adopting social processing depleting tasks tended to bias the ego-depletion effect size for different experimenters upward. This indicated that the association between these moderators was a result of a methodological artifact of particular studies rather than a systematic variation between studies. However, it must be stressed that the pattern of the differences was identical for the task presentation moderator analyses within the social processing and other tasks moderator groups. This means that the inclusion of these particular tasks was not exclusively responsible for the significantly larger ego-depletion effect among studies using different experimenters. Furthermore, the analyses including different experimenters comprised comparatively small samples of studies and should be interpreted with caution. On the basis of this analysis, researchers adopting the dual-task paradigm should include additional checks to ascertain the extent of participants'

perceived fulfillment of experimenter demands. Although participants in the present sample of studies were typically probed for suspicion regarding links between the two tasks, few studies reported whether participants thought they had satisfied the experimenter's demands after the initial task. In addition, few studies reported effort exerted on both the initial and second tasks. This would provide useful information to complement the use of different experimenters as a means to evaluate the experimenter-demand hypothesis.

Alternative Explanations

Our analysis also examined motivation, fatigue, self-efficacy, and affect as alternative explanations for the ego-depletion effect and how these explanations compared with the limited-resource account offered by the strength model. Present findings provide clear evidence that the impairment of task performance observed in ego-depletion experiments coincides with increased perceptions of fatigue, difficulty, and effort. Such perceptions substantiate the greater demand that self-control tasks relative to control condition tasks place on individuals' resources and are often used as manipulation checks in the dual-task paradigm (Baumeister et al., 1998; Govorun & Payne, 2006). These findings also corroborate research in related fields. For example, significant relations have been found between cognitive performance and other indices of fatigue like sleep deprivation (Barber, Munz, Bagsby, & Powell, 2009; Drummond et al., 2005) and mental fatigue (Ackerman & Kanter, 2009). Fatigue therefore serves as an indicator of the increased demands that self-control tasks place on individuals. This is not inconsistent with a limited resource account for self-control failure. Self-regulation requires considerable effort, placing increased demands on self-control resources. The depletion of resources is likely to lead to subjective fatigue and a reason why subsequent attempts at self-control fail. The prospect of future tasks will also be perceived as more daunting when the individual is fatigued, so future self-control tasks appear more difficult. Fatigue is expected to serve as a mediating factor in the effect of self-control resource depletion on task performance (Muraven et al., 1998), but there have been no formal tests of this effect.

Reduced motivation has been proposed as a further alternative explanation for self-regulatory failure, and fatigue may play an important supporting role. According to a motivation-only explanation, performing difficult and effortful tasks leads to a state of mental fatigue and reduces the perceived importance of subsequent task goals relative to the expected effort required. This results in decreased motivation to perform subsequent tasks that are perceived to be difficult, effortful, and fatiguing. By analogy, providing incentives or emphasizing the importance of task goals increases motivation to engage in such tasks by providing reasons to overcome fatigue and invest effort in attaining task goals. Consistent with this theory, present findings indicate that incentives or raising the importance of task goals reduced the deleterious effect of ego depletion on self-control task performance. Motivation therefore provides a viable explanation for the decrements in task performance observed in ego-depletion experiments.

According to the strength model, the limited resource and motivational explanations for ego depletion are not irreconcilable. The depletion of a limited self-control resource may be involved in inducing perceptions of fatigue, and this in turn results in decreased motivation to exert future self-control and regulatory failure on subsequent tasks. There are two reasons for this effect from the strength model perspective. First, depletion of self-control resources leads to comparatively higher perceptions of the effort required to engage in future acts of self-control, because doing so is relatively costly when resources are scarce compared to when they are plentiful. Second, engaging in self-control tasks reduces the availability of resources. This leads to increased motivation to conserve resources for times of need and reduced willingness to allocate further resources on tasks perceived to be unimportant. In contrast, providing incentives or increasing the importance of a task may result in increased motivation to commit further self-control resources to reach task goals in spite of the relatively high cost. Individuals are therefore more inclined to allocate their precious reserves because the task goal is perceived to be well worth the effort. However, while this integrated motivation and limited resource account may offer a solution in drawing together these competing explanations, the present synthesis does not provide unequivocal support for this model. The evidence presented here suggests that a motivation-only account of self-regulatory failure in the dual-task paradigm holds as a viable alternative explanation to the strength model.

The problem is that self-control capacity as a limited resource has only been measured indirectly, meaning that the ego-depletion effect has been exclusively inferred from postdepletion performance on self-control tasks. Current data, therefore, cannot verify whether the motivation-only and strength models provide exclusive explanations for the performance decrements observed on self-control tasks in ego-depletion experiments. Both models suggest that engaging in debilitating tasks is a source of fatigue that results in reduced motivation to engage in subsequent tasks. The motivation-only account suggests that the fatigue leads to a perceived imbalance between the effort required to achieve the goal and its value. The strength model suggests that this imbalance is due to reduced capacity to allocate depleted self-control resources to the task and increased motivation to conserve those resources. Until an objective measure of resource depletion has been identified, evidence to reconcile these competing explanations for the ego-depletion effect is likely to remain elusive.

Self-efficacy has also been proposed as an alternative explanation for ego depletion. People may have sufficient outcome expectancies regarding self-control tasks, but their perceived capacity to exert the necessary effort to attain task goals is diminished when they are in an ego-depleted state. The present analysis did not find a significant effect of self-efficacy on ego depletion. Furthermore, one study that attempted to change self-efficacy beliefs by providing bogus feedback regarding task performance found no significant effects (H. M. Wallace & Baumeister, 2002). Although the limited number of tests does not unequivocally rule out self-efficacy as a potential mediator of ego depletion, there is little support for it based on the evidence presented in the literature and in the current analysis.

A further alternative explanation for a decrease in performance across tasks may be due to negative affect. Present results revealed that negative affect is significantly related to ego depletion, with a small, homogeneous effect size. It seems that engaging in self-control tasks may induce negative affect, regardless as to whether the task itself requires affect regulation, which is consistent with expectations given their aversive nature (Tice & Bratslavsky,

2000). This would point to an explanation in which ego depletion was the result of coping with a negative affective state. Recent research has suggested that process behind the link between negative affective states and self-control failure is due to the depleting nature of active mood regulation. People are not able to commit resources to the second self-control task because attempts to regulate the negative affect induced by the initial task drain self-control resources (Bruyneel et al., 2009). Few studies in the present sample, however, reported relations between negative affect and task performance. This negated a formal test of mediation of the effect of ego depletion on task performance by negative affect. Although there are tests of this mediation effect in the ego-depletion literature (e.g., Gailliot et al., 2006), they are relatively uncommon, and researchers are encouraged to investigate the mediating role of negative affect in future ego-depletion studies.

Engaging in effortful, aversive tasks in ego-depletion experiments was not related to positive affect. Ego depletion does not undermine positive mood in the same way that it appears to induce negative affect. However, research has found that inducing positive affect is effective in overcoming the deleterious effects of self-control resource depletion (Tice, Baumeister, Shmueli, & Muraven, 2007). Positive affect may lead to renewed vigor toward tasks such that individuals increase their efforts and motivation to expend self-control resources in their pursuit. Alternatively, the induction of a positive mood may obviate the need to commit self-control resources to overcome the negative affect induced by the self-control tasks. In contrast, there is evidence that inducing a positive mood does not promote better self-control (Schmeichel & Vohs, 2009). Tests of positive affect induction as means to overcome ego depletion are relatively scarce, and additional empirical investigation is warranted to resolve the inconsistency.

Additional Strength-Model Hypotheses

The present analysis tested additional hypotheses that have emerged from the strength model. These hypotheses are meant to provide a more complete explanation of self-regulatory failure from a resource depletion perspective and assist in developing an understanding of the mechanisms that underpin the ego-depletion effect. In this section we evaluate the extent to which these hypotheses are supported by the present meta-analysis and the implications for the strength model.

Conservation. The strength model proposes that people attempt to conserve self-control resources when they are aware of forthcoming demands on their reserves. The depletion of self-control in the strength model is viewed as temporary and may result from complete depletion of finite self-control reserves or, alternatively, partial depletion when people conserve their reserves for future exertions (Baumeister & Heatherton, 1996; Muraven & Baumeister, 2000). Present results support the partial-depletion model. Individuals tend to modulate the application of self-control resources when faced with the prospect of future demand. This tendency is clearly adaptive from a limited resource perspective, as it maximizes the application of self-control resources and produces economy of effort. It is also consistent with an integrated motivational and limited resource account for ego depletion. Just as incentives can increase motivation to invest increased effort and allocate further self-control reserves postdepletion, future expectation motivates the conservation of resources, particularly when those reserves are depleted. This is because, when one's reserves are depleted, even a small outlay of resources is considered relatively costly. The sample of the effect sizes testing this hypothesis is comparatively small and comes from two studies (Muraven, Shmueli, & Burkely, 2006; Tyler & Burns, 2009), so it is important that this effect is replicated in a more diverse range of self-control tasks.

Training. According to the strength model, regular training on tasks requiring self-control will improve a person's capacity to exert self-control, just as training a muscle increases its strength and endurance (Baumeister & Heatherton, 1996; Baumeister et al., 2000). As expected, our analysis indicated that regular training resulted in significantly superior postdepletion self-control performance relative to that of untrained controls. A diverse range of training techniques to improve self-control was identified. This is important, as it not only supports the training hypothesis but provides further support for the premise that self-control draws from a common, global resource. Just as tasks from different spheres can deplete self-control strength, so regular training on self-control tasks in different spheres can help increase the capacity to exert self-control.

The mechanism that underlies the training hypothesis remains elusive. As yet, it is unclear whether training improves efficiency in the application of finite self-control resources to self-control tasks, perhaps through the development of self-control "skills," or whether the pool is just extended such that more of the self-control resource is available. Future tests may examine the effect of training on repeated self-control tasks that may address the efficiency versus "extended pool" question. This may also shed light on whether self-control is akin to a skill rather than a limited resource. Research may also examine whether ceasing training results in self-control capacity returning to baseline. This will provide useful further information on the processes by which training affects ego depletion and the longevity of the effect. Finally, future studies should seek to investigate whether the increase in self-control capacity as a result of training is linearly proportional to the duration of the training period. Preliminary evidence has been provided by Oaten and Cheng (2006b, 2007), who found steadily decreasing levels of ego depletion within trained participants at multiple time points during an extended training intervention. Additional multicohort within-participants training studies may provide further data to support this hypothesis.

Recovery. In the original conceptualization of the strength model, Baumeister and colleagues (Baumeister & Heatherton, 1996; Muraven & Baumeister, 2000) proposed that sufficient recovery is necessary after resource depletion for self-regulatory capacity to be restored. We investigated this in present analysis by coding studies as those that required the completion of questionnaires between tasks, equivalent to a brief rest, a filler task, or rest period between self-control tasks, and those that reported no interim period. Ego depletion did not vary across the questionnaire completion and filler task groups; however, contrary to hypotheses, the no-reported-interim group had lower levels of ego depletion. These results seem to suggest that immediate engagement in tasks results in less resource depletion, which is inconsistent with the recovery hypothesis. As we emphasized earlier, our coding of intertask duration was relatively crude, as there is likely to be considerable interindividual variation in questionnaire and filler

task completion time. Furthermore, the nonreporting of an interim period is not equivalent to the absence of an interim period. A more effective means of testing the role of recovery on ego depletion would be the inclusion of recovery or relaxation manipulations in the dual-task paradigm. Studies have demonstrated reduced ego depletion among participants receiving recovery manipulations (Oaten et al., 2008; Tyler & Burns, 2008), but there were insufficient effects for a meta-analysis. There is clearly a need for additional studies testing the role of recovery and relaxation. There is also a need to examine the effect of chronic lack of recovery on self-control capacity. For example, Baumeister and Heatherton (1996) suggested that sleep may assist in recovery from self-control resource depletion and that sleep deprivation may lead to failure to recover and a chronic state of ego depletion (C. Anderson, 2009; Barber et al., 2009; Wright, 2009).

Glucose and glucose supplementation. A recent avenue of inquiry in the pursuit of the mechanisms that govern ego depletion has been the identification of physiological mediators and moderators. Most prominent is the proposed role of blood glucose as a mediator of the effect of ego depletion on self-control task performance in the dual-task paradigm (Dvorak & Simons, 2009). Gailliot and Baumeister (2007a) have suggested that as self-control tasks require increased cerebral functioning, they may cause a concomitant rise in the demand for glucose in the brain (Benton, Parker, & Donohoe, 1996; Green, Elliman, & Rogers, 1997). They proposed that changes in blood glucose levels as a consequence of engaging in self-control tasks in dual-task paradigm experiments may serve as a proxy measure of this demand. Results of the present meta-analysis indicate that blood glucose levels were significantly associated with ego depletion. However, there are two caveats to bear in mind when interpreting these findings. First, the data are from a limited number of effect sizes ($k = 5$) and only two studies (Dvorak & Simons, 2009; Gailliot, Baumeister, et al., 2007), albeit from separate laboratories. Second, the studies did not measure glucose consumption in the brain, and this would be necessary to validate the proposed mechanism. Conclusions based on these data should not, therefore, be treated as unequivocally supportive of glucose as a physiological indicator of the ego-depletion effect.

An additional finding in the present analysis was that glucose supplementation allayed the effects of ego depletion on self-control task performance. This also provides limited evidence for glucose as a control mechanism for self-regulatory resource depletion. Nevertheless, there may be a number of plausible alternative explanations for this effect. For example, the consumption of beverages rich in sugar is associated with increased positive affect (Benton, 2002) and may have resulted in a concomitant increase in motivation to perform subsequent tasks. Similarly, researchers have proposed that it is the perception of glucose in the mouth cavity, as opposed to ingestion and substrate use, that leads to increased exertion on tasks (Pottier, Bouckaert, Gilis, Roels, & Derave, 2010). In summary, although present results provide preliminary evidence that blood glucose and glucose supplementation are implicated in the effect of ego-depletion on self-control task performance, the aforementioned caveats and alternative explanations mean that these findings should be regarded as tentative and not indicative of direct evidence for role of glucose as a mechanism for the ego-depletion effect.

Limitations and Future Directions

A limitation of the present analysis is that some of the effect sizes reported were based on relatively small sample sizes. As simulation studies have demonstrated that meta-analyses based on small samples of studies tend to bias the effect size upward (Reynolds & Day, 1984), caution should be exercised in interpreting the size of the effects in some of the subanalyses in the present research. In particular, analyses of the conservation, training, and glucose supplementation moderator groups were based on sets of studies numbering as few as five. Although these effects were corrected for statistical artifacts, the potential for one or two effects to alter the size and distribution of the averaged effect size remains. Replication of these effects in different spheres of self-control should be a priority for future investigation.

The present meta-analysis has assisted in identifying gaps in the ego-depletion literature and priorities for future research. An outstanding issue is the longevity of the ego-depletion effect and the need to reconcile the long- and short-term effects of self-control resource depletion. Baumeister and coworkers (Baumeister et al., 1998; Muraven et al., 1998) explicitly align the strength model with short-term depletion of self-control resources. It is clear that the dual-task paradigm and experimental tests of the theory have been geared toward testing such a model by adopting tasks typically less than 10 minutes in duration (Vohs et al., 2008). However, it is unclear what effects chronic self-control efforts have on ego depletion. It is difficult to distinguish between conditions that lead to the observation of a training effect and improvements in self-control and those that lead to long-term fatigue and decrements in self-control performance. For example, Vohs and Heatherton (2000) proposed that "repeated attempts at inhibition render a person especially vulnerable to situational temptations" (p. 249). They surmised that long-term dieters were compelled to engage in the chronic inhibition of the impulse to eat and would therefore be more vulnerable to depletion. In contrast, the training hypothesis proposes that long-term practice on self-control increases resistance to the deleterious effects of self-control exertion on task performance (Muraven et al., 1999; Oaten & Cheng, 2006a, 2006b, 2007). If the latter is the case, would dieters not be expected to be more effective in controlling their desire to eat if they have had long-term experience with resisting temptation? A possible reason for this inconsistency may be differences in the relative frequency and success of the long-term inhibitory experiences. Training effects have usually been observed after a series of relatively discrete and planned acts of self-control with sufficient recovery allowing for gradual improvement. Furthermore, in training studies participants are invariably successful in the self-control tasks they perform. The self-control acts are therefore experienced as finite quanta of successful self-regulation with sufficient time for recovery before the next act. In contrast, long-term acts of self-control in real-world contexts such as dieting are likely lead to frequent and unplanned attempts to resist temptations throughout the day. Furthermore, there is likely to be greater variation in the frequency of success, and dieters may experience long-term failed attempts to self-regulate with little opportunity to recover. In strength model vernacular, this may be the equivalent of "overtraining" resulting in a chronically-depleted state. Empirical support for these proposed mechanisms is necessary to resolve this inconsistency.

Further research should also identify the conditions that lead to the attenuating effect of motivation on ego depletion. If motivation compels individuals to tap further into their finite self-control reserves, as suggested by the findings of the present analysis, it is unlikely that they will be able to stave off the depleting effects of self-control tasks indefinitely. Evidence for this comes from research demonstrating that performance on vigilance tasks declines steadily over time (See et al., 1995). The effect of motivation on repeated bouts of self-control exertion needs to be tested to delineate the boundary conditions of motivation as a strategy to allay ego depletion. It is also important that the conservation of self-control resources is studied in conjunction with motivation. For example, will people anticipating a future self-control task still conserve their self-control resources if they are provided with an incentive to perform the second task? Or will they forgo the tendency to conserve resources and expend more of their reserves because they have increased motivation to perform the task?

The present analysis did not include individual differences in self-control as a moderator of the ego-depletion effect due to the limited number of tests of the effect. Research suggests that dispositional self-control may moderate the deleterious effects of situationally induced self-control resource depletion on subsequent task performance (Dvorak & Simons, 2009; Friese & Hofmann, 2009; Gailliot & Baumeister, 2007b; Gailliot, Schmeichel, & Maner, 2007). This is consistent with a limited capacity model of self-control. Dispositional self-control likely reflects the extent of an individual's self-control reserves and therefore determines the potential resources available for allocation to self-control tasks. This trait-level capacity has also been related to long-term self-regulatory efforts (Tangney et al., 2004). Future research should provide further tests of the interaction between ego depletion and trait self-control on task performance using the dual-task paradigm. This will assist in further integrating dispositional and situational influences on self-control performance.

The strength model may provide only a partial explanation for self-control failure. Current data support a limited resource account for short-term self-control depletion but do not unequivocally support or falsify alternative explanations such as motivation-only and coping with negative affect. Integrating the strength model with other theories may provide more comprehensive explanations of self-regulation. For example, theorists have recently proposed the integration of the strength model and dual-process models of behavioral decision making (Dvorak & Simons, 2009; Hagger, Wood, Stiff, & Chatzisarantis, 2009; Masicampo & Baumeister, 2008; Pocheptsova et al., 2009). In such models, behavior is viewed as a function of effortful, intentional decisions that require deliberation and information processing (reflective route) and reactive responses that are spontaneous, unplanned and reliant on heuristic processing (impulsive route; Hofmann, Friese, & Strack, 2009; Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). Self-control is conceptualized as a deliberate and intentional attempt to override and gain control over impulsive responses driven by situational cues and immediate rewards. Engaging in behaviors that require overcoming dominant responses and focused commitment on long-term goal attainment is therefore most effectively controlled by the reflective route requiring motivation and effort. Resource depletion may be a mechanism that determines whether actions are determined by reflective rather than impulsive routes to behavior. A lack of self-control resources decreases the propensity of the reflective pathway to override the influence of the impulsive pathway on behavior. This is likely to result in behavior becoming increasingly determined by the impulsive route and in reduced persistence on long-term, planned behaviors (Dvorak & Simons, 2009). These developments are the beginnings of endeavors to unify theories of self-control to resolve inconsistencies and provide complementary explanations of behavior.

Conclusion

The present meta-analysis provides evidence to suggest that the strength model is a useful explanatory system with which to understand self-control, but further refinements may be necessary, particularly when it comes to the identification of mechanisms. For example, the present analysis could not unequivocally rule out other explanations for ego depletion, such as motivation only and negative affect. These alternatives are not necessarily inconsistent with a resource depletion account and may provide insight into the possible processes that underpin ego depletion. It is also important to note that support for self-control as a limited resource has only been inferred indirectly from performance decrements on self-control tasks (Schmeichel, Demaree, Robinson, & Pu, 2006). Identifying physiological analogs for ego depletion may offer a potential solution. The finding that blood glucose varies with ego depletion, for example, provides preliminary evidence linking self-control strength to a physical resource (Dvorak & Simons, 2009; Gailliot, Baumeister, et al., 2007). These results have been complemented by research that has linked physiological analogs for effort including electromyographic activity (Bray et al., 2008), cardiovascular response (Segerstrom & Nes, 2007; Wright et al., 2008), and galvanic skin response (Sheppes, Catran, & Meiran, 2009) with ego depletion. Such evidence is consistent with Baumeister et al.'s (1998) prediction that it is "implausible that ego depletion would have no physiological aspect or correlates at all" (p. 1263). In practical terms, these explanations and mechanisms may provide insight into strategies that can be used to overcome ego depletion. Intervention techniques to increase motivation and promote regular practice on self-control tasks are means that have been suggested to improve self-control capacity (Hagger et al., 2009; Hui et al., 2009; Muraven & Slessareva, 2003). The strength model offers promise in identifying strategies to minimize short-term decrements in self-control and assist in developing interventions that foster better self-regulation.

References

For a complete list of list of studies included in the meta-analysis, go to http://dx.doi.org/10.1037/a0019486.supp

Ackerman, P. L., & Kanter, R. (2009). Test length and cognitive fatigue: An empirical examination of effects on performance and test-taker reactions. *Journal of Experimental Psychology: Applied, 15,* 163–181. doi:10.1037/a0015719

Aguinis, H., & Pierce, C. A. (1998). Testing moderator variable hypotheses meta-analytically. *Journal of Management, 24,* 577–592. doi:10.1177/014920639802400501

Ainslie, G. (1975). Specious reward: A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin, 82,* 463–496. doi:10.1037/h0076860

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior.

In J. Kuhl & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp. 11–39). Heidelberg, Germany: Springer-Verlag.

Anderson, C. (2009). The impact of sleep on dealing with daily stressors: A need for controlled laboratory evidence. *Stress and Health.* Advance online publication. doi:10.1002/smi.1301

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review, 89,* 369–406. doi:10.1037/0033-295X.89.4.369

Bagozzi, R. P. (1992). The self-regulation of attitudes, intentions and behavior. *Social Psychology Quarterly, 55,* 178–204.

Barber, L., Munz, D., Bagsby, P., & Powell, E. (2009). Sleep consistency and sufficiency: Are both necessary for less psychological strain? *Stress and Health.* Advance online publication. doi:10.1002/smi.1292

Barnett, V., & Lewis, T. (1994). *Outliers in statistical data* (3rd ed.). Chichester, England: Wiley.

Baumeister, R. F. (2002). Ego depletion and self-control failure: An energy model and the self's executive function. *Self and Identity, 1,* 129–136. doi:10.1080/152988602317319302

Baumeister, R. F. (2003). Ego depletion and self-regulation failure: A resource model of self-control. *Alcoholism: Clinical and Experimental Research, 27,* 281–284. doi:10.1097/01.alc.0000060879.61384.a4

Baumeister, R. F. (2005). *The cultural animal: Human nature, meaning, and social life.* New York, NY: Oxford University Press.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74,* 1252–1265. doi:10.1037/0022-3514.74.5.1252

Baumeister, R. F., Gailliot, M. T., DeWall, C. N., & Oaten, M. (2006). Self-regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality, 74,* 1773–1801. doi:10.1111/j.1467-6494.2006.00428.x

Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: An overview. *Psychological Inquiry, 7,* 1–15. doi:10.1207/s15327965pli0701_1

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation.* San Diego, CA: Academic.

Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Social Cognition, 18,* 130–150.

Baumeister, R. F., Sparks, E. A., Stillman, T. F., & Vohs, K. D. (2008). Free will in consumer behavior: Self-control, ego depletion, and choice. *Journal of Consumer Psychology, 18,* 4–13. doi:10.1016/j.jcps.2007.10.002

Baumeister, R. F., & Vohs, K. D. (2007). Self-regulation, ego-depletion, and motivation. *Social and Personality Psychology Compass, 1,* 115–128. doi:10.1111/j.1751-9004.2007.00001.x

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science, 16,* 351–355. doi:10.1111/j.1467-8721.2007.00534.x

Benton, D. (2002). Carbohydrate ingestion, blood glucose and mood. *Neuroscience and Biobehavioral Reviews, 26,* 293–308. doi:10.1016/S0149-7634(02)00004-0

Benton, D., Parker, P. Y., & Donohoe, R. T. (1996). The supply of glucose to the brain and cognitive functioning. *Journal of Biosocial Science, 28,* 463–479. doi:10.1017/S0021932000022537

Boksem, M. A. S., Meijman, T. F., & Lorist, M. M. (2006). Mental fatigue, motivation and action monitoring. *Biological Psychology, 72,* 123–132. doi:10.1016/j.biopsycho.2005.08.007

Bray, S. R., Ginis, K. A. M., Hicks, A. L., & Woodgate, J. (2008). Effects of self-regulatory strength depletion on muscular performance and EMG activation. *Psychophysiology, 45,* 337–343. doi:10.1111/j.1469-8986.2007.00625.x

Bruyneel, S. D., Dewitte, S., Franses, P. H., & Dekimpe, M. G. (2009). I felt low and my purse feels light: Depleting mood regulation attempts affect risk decision making. *Journal of Behavioral Decision Making, 22,* 153–170. doi:10.1002/bdm.619

Bruyneel, S. D., Dewitte, S., Vohs, K. D., & Warlop, L. (2006). Repeated choosing increases susceptibility to affective product features. *International Journal of Research in Marketing, 23,* 215–225. doi:10.1016/j.ijresmar.2005.12.002

Burkley, E. (2008). The role of self-control in resistance to persuasion. *Personality and Social Psychology Bulletin, 34,* 419–431. doi:10.1177/0146167207310458

Cameron, C. (1973). A theory of fatigue. *Ergonomics, 16,* 633–648. doi:10.1080/00140137308924554

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior.* New York, NY: Cambridge University Press.

Ciarocco, N. J., Sommer, K. L., & Baumeister, R. F. (2001). Ostracism and ego depletion: The strains of silence. *Personality and Social Psychology Bulletin, 27,* 1156–1163. doi:10.1177/0146167201279008

Cochran, W. G. (1952). The χ^2 test of goodness of fit. *Annals of Mathematical Statistics, 23,* 315–345. doi:10.1214/aoms/1177692778

Cohen, J. (1987). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

DeCoster, J. (2004). *Meta-analysis notes.* Retrieved from http://www.stathelp.com/notes.html

DeCoster, J., & Claypool, H. M. (2004). A meta-analysis of priming effects on impression formation supporting a general model of informational biases. *Personality and Social Psychology Review, 8,* 2–27. doi:10.1207/S15327957PSPR0801_1

DeWall, C. N., Baumeister, R. F., Gailliot, M. T., & Maner, J. K. (2008). Depletion makes the heart grow less helpful: Helping as a function of self-regulatory energy and genetic relatedness. *Personality and Social Psychology Bulletin, 34,* 1653–1662. doi:10.1177/0146167208323981

DeWall, C. N., Baumeister, R. F., Stillman, T. F., & Gailliot, M. T. (2007). Violence restrained: Effects of self-regulation and its depletion on aggression. *Journal of Experimental Social Psychology, 43,* 62–76. doi:10.1016/j.jesp.2005.12.005

Drummond, S. P., Bischoff-Grethe, A., Dinges, D. F., Ayalon, L., Mednick, S. C., & Meloy, M. J. (2005). The neural basis of the psychomotor vigilance task. *Sleep, 28,* 1059–1068.

Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16,* 939–944. doi:10.1111/j.1467-9280.2005.01641.x

Dvorak, R. D., & Simons, J. S. (2009). Moderation of resource depletion in the self-control strength model: Differing effects of two modes of self-control. *Personality and Social Psychology Bulletin, 35,* 572–583. doi:10.1177/0146167208330855

Eisenberg, N., Valiente, C., Fabes, R. A., Smith, C. L., Reiser, M., Shepard, S. A., . . . Cumberland, A. J. (2003). The relations of effortful control and ego control to children's resiliency and social functioning. *Developmental Psychology, 39,* 761–776. doi:10.1037/0012-1649.39.4.761

Fennis, B. M., Janssen, L., & Vohs, K. D. (2009). Acts of benevolence: A limited-resource account of compliance with charitable requests. *Journal of Consumer Research, 35,* 906–924. doi:10.1086/593291

Field, A. P. (2003). The problems using fixed-effects models of meta-analysis on real-world data. *Understanding Statistics, 2,* 105–124. doi:10.1207/S15328031US0202_02

Finkel, E. J., & Campbell, W. K. (2001). Self-control and accommodation in close relationships: An interdependence analysis. *Journal of Personality and Social Psychology, 81,* 263–277. doi:10.1037//0022-3514.81.2.263

Finkel, E. J., Dalton, A. N., Campbell, W. K., Brunell, A. B., Scarbeck, S. J., & Chartrand, T. L. (2006). High-maintenance interaction: Inefficient social coordination impairs self-regulation. *Journal of Personality and Social Psychology, 91,* 456–475. doi:10.1037/0022-3514.91.3.456

Finkel, E. J., DeWall, C. N., Slotter, E. B., Oaten, M., & Foshee, V. A. (2009). Self-regulatory failure and intimate partner violence perpetration. *Journal of Personality and Social Psychology, 97,* 483–499. doi:10.1037/a0015433

Fischer, P., Greitemeyer, T., & Frey, D. (2007). Ego depletion and positive illusions: Does the construction of positivity require regulatory resources? *Personality and Social Psychology Bulletin, 33,* 1306–1321. doi:10.1177/0146167207303025

Fischer, P., Greitemeyer, T., & Frey, D. (2008). Self-regulation and selective exposure: The impact of depleted self-regulation resources on confirmatory information processing. *Journal of Personality and Social Psychology, 94,* 382–395. doi:10.1037/0022-3514.94.3.382

Fishbach, A., Friedman, R. S., & Kruglanski, A. W. (2003). Leading us not unto temptation: Momentary allurements elicit overriding goal activation. *Journal of Personality and Social Psychology, 84,* 296–309. doi:10.1037/0022-3514.84.2.296

Fishbach, A., & Labroo, A. A. (2007). Be better or be merry: How mood affects self-control. *Journal of Personality and Social Psychology, 93,* 158–173. doi:10.1037/0022-3514.93.2.158

Folkman, S., & Moskowitz, J. T. (2000). Positive affect and the other side of coping. *American Psychologist, 55,* 647–654. doi:10.1037/0003-066X.55.6.647

Friese, M., & Hofmann, W. (2009). Control me or I will control you: Impulses, trait self-control, and the guidance of behavior. *Journal of Research in Personality, 43,* 795–805. doi:10.1016/j.jrp.2009.07.004

Friese, M., Hofmann, W., & Wanke, M. (2008). When impulses take over: Moderated predictive validity of explicit and implicit attitude measures in predicting food choice and consumption behaviour. *British Journal of Social Psychology, 47,* 397–419. doi:10.1348/014466607x241540

Fujita, K., & Han, H. A. (2009). Moving beyond deliberative control of impulses: The effect of construal levels on evaluative associations in self-control conflicts. *Psychological Science, 20,* 799–804. doi:10.1111/j.1467-9280.2009.02372.x

Funder, D. C., Block, J. H., & Block, J. (1983). Delay of gratification: Some longitudinal personality correlates. *Journal of Personality and Social Psychology, 44,* 1198–1213. doi:10.1037/0022-3514.44.6.1198

Gailliot, M. T., & Baumeister, R. F. (2007a). The physiology of willpower: Linking blood glucose to self-control. *Personality and Social Psychology Review, 11,* 303–327. doi:10.1177/1088868307303030

Gailliot, M. T., & Baumeister, R. F. (2007b). Self-regulation and sexual restraint: Dispositionally and temporarily poor self-regulatory abilities contribute to failures at restraining sexual behavior. *Personality and Social Psychology Bulletin, 33,* 173–186. doi:10.1177/0146167206293472

Gailliot, M. T., Baumeister, R. F., DeWall, C. N., Maner, J. K., Plant, E. A., Tice, D. M., . . . Schmeichel, B. J. (2007). Self-control relies on glucose as a limited energy source: Willpower is more than a metaphor. *Journal of Personality and Social Psychology, 92,* 325–336. doi:10.1037/0022-3514.92.2.325

Gailliot, M. T., Peruche, M., Plant, E. A., & Baumeister, R. F. (2009). Stereotypes and prejudice in the blood: Sucrose drinks reduce prejudice and stereotyping. *Journal of Experimental Social Psychology, 45,* 288–290. doi:10.1016/j.jesp.2008.09.003

Gailliot, M. T., Plant, E. A., Butz, D. A., & Baumeister, R. F. (2007). Increasing self-regulatory strength can reduce the depleting effect of suppressing stereotypes. *Personality and Social Psychology Bulletin, 33,* 281–294. doi:10.1177/0146167206296101

Gailliot, M. T., Schmeichel, B. J., & Baumeister, R. F. (2006). Self-regulatory processes defend against the threat of death: Effects of self-control depletion and trait self-control on thoughts and fears of dying. *Journal of Personality and Social Psychology, 91,* 49–62. doi:10.1037/0022-3514.91.1.49

Gailliot, M. T., Schmeichel, B. J., & Maner, J. K. (2007). Differentiating the effects of self-control and self-esteem on reactions to mortality salience. *Journal of Experimental Social Psychology, 43,* 894–901. doi:10.1016/j.jesp.2006.10.011

Geeraert, N., & Yzerbyt, V. Y. (2007). How fatiguing is dispositional suppression? Disentangling the effects of procedural rebound and ego-depletion. *European Journal of Social Psychology, 37,* 216–230. doi:10.1002/ejsp.349

Gordijn, E. H., Hindriks, I., Koomen, W., Dijksterhuis, A., & Van Knippenberg, A. (2004). Consequences of stereotype suppression and internal suppression motivation: A self-regulation approach. *Personality and Social Psychology Bulletin, 30,* 212–224. doi:10.1177/0146167203259935

Govorun, O., & Payne, B. K. (2006). Ego-depletion and prejudice: Separating automatic and controlled components. *Social Cognition, 24,* 111–136. doi:10.1521/soco.2006.24.2.111

Green, M. W., Elliman, N. A., & Rogers, P. J. (1997). The effects of food deprivation and incentive motivation on blood glucose levels and cognitive function. *Psychopharmacology, 134,* 88–94. doi:10.1007/s002130050429

Grubbs, F. E. (1950). Sample criteria for testing outlying observations. *Journal of the American Statistical Association, 21,* 27–58.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2009). The strength model of self-regulation failure and health-related behavior. *Health Psychology Review, 3,* 208–238. doi:10.1080/17437190903414387

Hammer, E. Y. (2005). From the laboratory to the classroom and back: The science of interpersonal relationships informs teaching. *Journal of Social and Clinical Psychology, 24,* 3–10. doi:10.1521/jscp.24.1.3.59168

Hedges, L. V., & Olkin, I. (1983). Regression models in research synthesis. *American Statistician, 37,* 137–140.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis.* Orlando, FL: Academic Press.

Henden, E. (2008). What is self-control? *Philosophical Psychology, 21,* 69–90. doi:10.1080/09515080701874092

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine, 21,* 1539–1558. doi:10.1002/sim.1186

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal, 327,* 557–560. doi:10.1136/bmj.327.7414.557

Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science, 4,* 162–176. doi:10.1111/j.1745-6924.2009.01116.x

Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review, 2,* 111–137. doi:10.1080/17437190802617668

Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation: Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of eating behavior. *Journal of Experimental Social Psychology, 43,* 497–504. doi:10.1016/j.jesp.2006.05.004

Huedo-Medina, T. B., Sánchez-Meca, J., Marín-Martínez, F., & Botella, J. (2006). Assessing heterogeneity in meta-analysis: Q statistic or I^2 index? *Psychological Methods, 11,* 193–206. doi:10.1037/1082-989X.11.2.193

Hui, S.-K. A., Wright, R. A., Stewart, C. C., Simmons, A., Eaton, B., & Nolte, R. N. (2009). Performance, cardiovascular, and health behavior effects of an inhibitory strength training intervention. *Motivation and Emotion, 33,* 419–434. doi:10.1007/s11031-009-9146-0

Hullett, C. R., & Levine, T. R. (2003). The overestimation of effect sizes from F values in meta-analysis: The cause and solution. *Communication Monographs, 70,* 52–67. doi:10.1080/715114664

Hunter, J. E., & Schmidt, F. (1994). *Methods of meta-analysis: Correcting error and bias in research findings* (2nd ed.). Newbury Park, CA: Sage.

Hunter, J. E., & Schmidt, F. L. (2000). Fixed effects vs. random effects meta-analysis models: Implications for cumulative research knowledge in psychology. *International Journal of Selection and Assessment, 8,* 275–292. doi:10.1111/1468-2389.00156

Johns, M., Inzlicht, M., & Schmader, T. (2008). Stereotype threat and executive resource depletion: Examining the influence of emotion regulation. *Journal of Experimental Psychology: General, 137,* 691–705. doi:10.1037/a0013834

Joireman, J., Balliet, D., Sprott, D., Spangenberg, E., & Schultz, J. (2008). Consideration of future consequences, ego-depletion, and self-control: Support for distinguishing between CFC-Immediate and CFC-Future sub-scales. *Personality and Individual Differences, 45,* 15–21. doi:10.1016/j.paid.2008.02.011

Kisamore, J. L., & Brannick, M. T. (2008). An illustration of the consequences of meta-analysis model choice. *Organizational Research Methods, 11,* 35–53. doi:10.1177/1094428106287393

Koestner, R., Bernieri, F., & Zuckerman, M. (1992). Self-regulation and consistency between attitudes, traits, and behaviors. *Personality and Social Psychology Bulletin, 18,* 52–59. doi:0.1177/0146167292181008

Leith, K. P., & Baumeister, R. F. (1996). Why do bad moods increase self-defeating behavior? Emotion, risk taking, and self-regulation. *Journal of Personality and Social Psychology, 71,* 1250–1267. doi:10.1037/0022-3514.71.6.1250

Levy, N. (2006). Addiction, autonomy and ego-depletion: A response to Bennett Foddy and Julian Savulescu. *Bioethics, 20,* 16–20. doi:10.1111/j.1467-8519.2006.00471.x

Lipsey, M. W. (2003). Those confounded moderators in meta-analysis: Good, bad, and ugly. *Annals of the American Academy of Political and Social Science, 587,* 69–81. doi:10.1177/0002716202250791

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes, 65,* 272–292. doi:10.1006/obhd.1996.0028

Logue, A. W. (1988). Research on self-control: An integrating framework. *Behavioral and Brain Sciences, 11,* 665–709. doi:10.1017/S0140525X00053978

Lorist, M. M., Boksem, M. A. S., & Ridderinkhof, K. R. (2005). Impaired cognitive control and reduced cingulate activity during mental fatigue. *Cognitive Brain Research, 24,* 199–205. doi:10.1016/j.cogbrainres.2005.01.018

Martijn, C., Alberts, H., Merckelbach, H., Havermans, R., Huijts, A., & De Vries, N. K. (2007). Overcoming ego depletion: The influence of exemplar priming on self-control performance. *European Journal of Social Psychology, 37,* 231–238. doi:10.1002/ejsp.350

Masicampo, E. J., & Baumeister, R. F. (2008). Toward a physiology of dual-process reasoning and judgment: Lemonade, willpower, and expensive rule-based analysis. *Psychological Science, 19,* 255–260. doi:10.1111/j.1467-9280.2008.02077.x

Mayer, J. D., & Gaschke, Y. N. (1988). The experience and meta-experience of mood. *Journal of Personality and Social Psychology, 55,* 102–111. doi:10.1037/0022-3514.55.1.102

Mead, N. L., Baumeister, R. F., Gino, F., Schweitzer, M. E., & Ariely, D. (2009). Too tired to tell the truth: Self-control resource depletion and dishonesty. *Journal of Experimental Social Psychology, 45,* 594–597. doi:10.1016/j.jesp.2009.02.004

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: The dynamics of willpower. *Psychological Review, 106,* 3–19. doi:10.1037/0033-295X.106.1.3

Mischel, W. (1996). From good intentions to willpower. In P. M. Gollwitzer & J. A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 197–218). New York, NY: Guilford Press.

Mischel, W., Shoda, Y., & Rodrieguez, M. L. (1989, May 26). Delay of gratification in children. *Science, 244,* 933–938. doi:10.1126/science.2658056

Moller, A. C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego depletion: The moderating role of autonomy. *Personality and Social Psychology Bulletin, 32,* 1024–1036. doi:10.1177/0146167206288008

Muraven, M. (2008a). Autonomous self-control is less depleting. *Journal of Research in Personality, 42,* 763–770. doi:10.1016/j.jrp.2007.08.002

Muraven, M. (2008b). Prejudice as self-control failure. *Journal of Applied Social Psychology, 38,* 314–333. doi:10.1111/j.1559-1816.2007.00307.x

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126,* 247–259. doi:10.1037/0033-2909.126.2.247

Muraven, M., Baumeister, R. F., & Tice, D. M. (1999). Longitudinal improvement of self-regulation through practice: Building self-control strength through repeated exercise. *Journal of Social Psychology, 139,* 446–457. doi:10.1080/00224549909598404

Muraven, M., Collins, R. L., & Nienhaus, K. (2002). Self-control and alcohol restraint: An initial application of the self-control strength model. *Psychology of Addictive Behaviors, 16,* 113–120.

Muraven, M., Collins, R. L., Shiffman, S., & Paty, J. A. (2005). Daily fluctuations in self-control demands and alcohol intake. *Psychology of Addictive Behaviors, 19,* 140–147. doi:10.1037/0893-164x.19.2.140

Muraven, M., Gagne, M., & Rosman, H. (2008). Helpful self-control: Autonomy support, vitality, and depletion. *Journal of Experimental Social Psychology, 44,* 573–585. doi:10.1016/j.jesp.2007.10.008

Muraven, M., Pogarsky, G., & Shmueli, D. (2006). Self-control depletion and the general theory of crime. *Journal of Quantitative Criminology, 22,* 263–277. doi:10.1007/s10940-006-9011-1

Muraven, M., Shmueli, D., & Burkley, E. (2006). Conserving self-control strength. *Journal of Personality and Social Psychology, 91,* 524–537. doi:10.1037/0022-3514.91.3.524

Muraven, M., & Slessareva, E. (2003). Mechanisms of self-control failure: Motivation and limited resources. *Personality and Social Psychology Bulletin, 29,* 894–906. doi:10.1177/0146167203253209

Muraven, M., Tice, D. M., & Baumeister, R. F. (1998). Self-control as a limited resource: Regulatory depletion patterns. *Journal of Personality and Social Psychology, 74,* 774–789. doi:10.1037/0022-3514.74.3.774

Neubach, B., & Schmidt, K. H. (2008). Main and interaction effects of different self-control demands on indicators of job strain. *Zeitschrift Fur Arbeits-Und Organisationspsychologie, 52,* 17–24. doi:10.1026/0932-4089.52.1.17

Oaten, M., & Cheng, K. (2006a). Improved self-control: The benefits of a regular program of academic study. *Basic and Applied Social Psychology, 28,* 1–16. doi:10.1207/s15324834basp2801_1

Oaten, M., & Cheng, K. (2006b). Longitudinal gains in self-regulation from regular physical exercise. *British Journal of Health Psychology, 11,* 717–733. doi:10.1348/135910706X96481

Oaten, M., & Cheng, K. (2007). Improvements in self-control from financial monitoring. *Journal of Economic Psychology, 28,* 487–501. doi:10.1016/j.joep.2006.11.003

Oaten, M., Williams, K. D., Jones, A., & Zadro, L. (2008). The effects of ostracism on self-regulation in the socially anxious. *Journal of Social and Clinical Psychology, 27,* 471–504. doi:10.1521/jscp.2008.27.5.471

Ostafin, B. D., Marlatt, G. A., & Greenwald, A. G. (2008). Drinking without thinking: An implicit measure of alcohol motivation predicts failure to control alcohol use. *Behavior Research and Therapy, 46,* 1210–1219. doi:10.1016/j.brat.2008.08.003

Parasuraman, R. (1979, August 31). Memory load and event rate control sensitivity decrements in sustained attention. *Science, 205,* 924–927. doi:10.1126/science.472714

Park, S. H., Glaser, J., & Knowles, E. D. (2008). Implicit motivation to control prejudice moderates the effect of cognitive depletion on unintended discrimination. *Social Cognition, 26,* 401–419. doi:10.1521/soco.2008.26.4.401

Pocheptsova, A., Amir, O., Dhar, R., & Baumeister, R. F. (2009). Deciding without resources: Resource depletion and choice in context. *Journal of Marketing Research, 46,* 344–355.

Pottier, A., Bouckaert, J., Gilis, W., Roels, T., & Derave, W. (2010). Mouth rinse but not ingestion of a carbohydrate solution improves 1-h cycle time trial performance. *Scandinavian Journal of Medicine & Science in Sports, 20,* 105–111. doi:10.1111/j.1600-0838.2008.00868.x

Reynolds, S., & Day, J. (1984, August). *Monte Carlo studies of effect size estimates and their approximation in meta-analysis.* Paper presented at

the meeting of the American Psychological Association, Toronto, Ontario, Canada.

Richeson, J. A., & Shelton, J. N. (2003). When prejudice does not pay: Effects of interracial contact on executive function. *Psychological Science, 14,* 287–290. doi:10.1111/1467-9280.03437

Richeson, J. A., & Trawalter, S. (2005). Why do interracial interactions impair executive function? A resource depletion account. *Journal of Personality and Social Psychology, 88,* 934–947. doi:10.1037/0022-3514.88.6.934

Richeson, J. A., Trawalter, S., & Shelton, J. N. (2005). African Americans' implicit racial attitudes and the depletion of executive function after interracial interactions. *Social Cognition, 23,* 336–352. doi:10.1521/soco.2005.23.4.336

Rosenbaum, D. A., Carlson, R. A., & Gilmore, R. O. (2001). Acquisition of intellectual and perceptual–motor skills. *Annual Review of Psychology, 52,* 453–470. doi:10.1146/annurev.psych.52.1.453

Rosenberg, M. S. (2005). The file-drawer problem revisited: A general weighted method for calculating fail-safe numbers in meta-analysis. *Evolution, 59,* 464–468. doi:10.1111/j.0014-3820.2005.tb01004.x

Sagie, A., & Koslowsky, M. (1993). Detecting moderators with meta-analysis: An evaluation and comparison of techniques. *Personnel Psychology, 46,* 629–640. doi:10.1111/j.1744-6570.1993.tb00888.x

Sánchez-Meca, J., & Marín-Martínez, F. (1997). Homogeneity tests in meta-analysis: A Monte Carlo comparison of statistical power and Type I error. *Quality and Quantity, 31,* 385–399. doi:10.1023/A:1004298118485

Sánchez-Meca, J., & Marín-Martínez, F. (1998). Testing continuous moderators in meta-analysis: A comparison of procedures. *Journal of Mathematical and Statistical Psychology, 51,* 311–326.

Sansone, C., & Smith, J. L. (2000). The "how" of goal pursuit: Interest and self-regulation. *Psychological Inquiry, 11,* 306–309. doi:10.1207/S15327965PLI1104_02

Schmeichel, B. J. (2007). Attention control, memory updating, and emotion regulation temporarily reduce the capacity for executive control. *Journal of Experimental Psychology: General, 136,* 241–255. doi:10.1037/0096-3445.136.2.241

Schmeichel, B. J., & Baumeister, R. F. (2004). Self-regulatory strength. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory and applications* (pp. 84–98). New York, NY: Guildford Press.

Schmeichel, B. J., Demaree, H. A., Robinson, J. L., & Pu, J. (2006). Ego depletion by response exaggeration. *Journal of Experimental Social Psychology, 42,* 95–102. doi:10.1016/j.jesp.2005.02.005

Schmeichel, B. J., & Vohs, K. D. (2009). Self-affirmation and self-control: Affirming core values counteracts ego depletion. *Journal of Personality and Social Psychology, 96,* 770–782. doi:10.1037/a0014635

Schmeichel, B. J., & Zell, A. (2007). Trait self-control predicts performance on behavioral tests of self-control. *Journal of Personality, 75,* 743–755. doi:10.1111/j.1467-6494.2007.00455.x

Schmidt, K. H., Neubach, B., & Heuer, H. (2007). Self-control demands, cognitive control deficits, and burnout. *Work and Stress, 21,* 142–154. doi:10.1080/02678370701431680

Schouwenburg, H. C. (2004). Academic procrastination: Theoretical notions, measurement, and research. In H. C. Schouwenburg, C. H. Lay, T. A. Pychyl, & J. R. Ferrari (Eds.), *Counseling the procrastinator in academic settings* (pp. 3–17). Washington, DC: American Psychological Association.

Schwarzer, R., & Jerusalem, M. (1995). Self-efficacy measurement: Generalized self-efficacy scale (GSES). In J. Weinman, S. Wright, & M. Johnston (Eds.), *Measures in health psychology: A user's portfolio* (pp. 35–37). Windsor, England: NFER-Nelson.

See, J. E., Howe, S. R., Warm, J. S., & Dember, W. N. (1995). Meta-analysis of the sensitivity decrement in vigilance. *Psychological Bulletin, 117,* 230–249. doi:10.1037/0033-2909.117.2.230

Seeley, E. A., & Gardner, W. I. (2003). The "selfless" and self-regulation: The role of chronic other-orientation in averting self-regulatory depletion. *Self and Identity, 2,* 103–117. doi:10.1080/15298860309034

Segerstrom, S. C., & Nes, L. S. (2007). Heart rate variability reflects self-regulatory strength, effort, and fatigue. *Psychological Science, 18,* 275–281. doi:10.1111/j.1467-9280.2007.01888.x

Shamosh, N. A., & Gray, J. R. (2007). The relation between fluid intelligence and self-regulatory depletion. *Cognition & Emotion, 21,* 1833–1843. doi:10.1080/02699930701273658

Sheppes, G., Catran, E., & Meiran, N. (2009). Reappraisal (but not distraction) is going to make you sweat: Physiological evidence for self-control effort. *International Journal of Psychophysiology, 71,* 91–96. doi:10.1016/j.ijpsycho.2008.06.006

Steel, P. (2007). The nature of procrastination: A meta-analytic and theoretical review of quintessential self-regulatory failure. *Psychological Bulletin, 133,* 65–94. doi:10.1037/0033-2909.133.1.65

Stewart, C. C., Wright, R. A., Hui, S.-K. A., & Simmons, A. (2009). Outcome expectancy as a moderator of mental fatigue influence on cardiovascular response. *Psychophysiology, 46,* 1141–1149. doi:10.1111/j.1469-8986.2009.00862.x

Stillman, T. F., Tice, D. M., Fincham, F. D., & Lambert, N. M. (2009). The psychological presence of family improves self-control. *Journal of Social and Clinical Psychology, 28,* 498–529. doi:10.1521/jscp.2009.28.4.498

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8,* 220–247. doi:10.1207/s15327957pspr0803_1

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–661. doi:10.1037/h0054651

Stucke, T. S., & Baumeister, R. F. (2006). Ego depletion and aggressive behavior: Is the inhibition of aggression a limited resource? *European Journal of Social Psychology, 36,* 1–13. doi:10.1002/ejsp.285

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72,* 271–324. doi:10.1111/j.0022-3506.2004.00263.x

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43,* 379–384. doi:10.1016/j.jesp.2006.05.007

Tice, D. M., & Bratslavsky, E. (2000). Giving in to feel good: The place of emotion regulation in the context of general self-control. *Psychological Inquiry, 11,* 149–159. doi:10.1207/S15327965PLI1103_03

Tice, D. M., Bratslavsky, E., & Baumeister, R. F. (2001). Emotional distress regulation takes precedence over impulse control: If you feel bad, do it! *Journal of Personality and Social Psychology, 80,* 53–67. doi:10.1037/0022-3514.80.1.53

Tops, M., Lorist, M. M., Wijers, A. A., & Meijman, T. F. (2004). To stress or relax: Neurochemical aspects of activity and rest. *Gedrag en Organisatie, 17,* 32–42.

Trawalter, S., & Richeson, J. A. (2006). Regulatory focus and executive function after interracial interactions. *Journal of Experimental Social Psychology, 42,* 406–412. doi:10.1016/j.jesp.2005.05.008

Tyler, J. M. (2008). In the eyes of others: Monitoring for relational value cues. *Human Communication Research, 34,* 521–534. doi:10.1111/j.1468-2958.2008.00331.x

Tyler, J. M., & Burns, K. C. (2008). After depletion: The replenishment of the self's regulatory resources. *Self and Identity, 7,* 305–321. doi:10.1080/15298860701799997

Tyler, J. M., & Burns, K. C. (2009). Triggering conservation of the self's regulatory resources. *Basic and Applied Social Psychology, 31,* 255–266. doi:10.1080/01973530903058490

Vohs, K. D. (2006). Self-regulatory resources power the reflective system:

Evidence from five domains. *Journal of Consumer Psychology, 16,* 217–223. doi:10.1207/s15327663jcp1603_3

Vohs, K. D., & Baumeister, R. F. (2004). Ego-depletion, self-control, and choice. In J. Greenberg, S. L. Koole, & T. Pyszczynski (Eds.), *Handbook of experimental existential psychology* (pp. 398–410). New York, NY: Guilford Press.

Vohs, K. D., Baumeister, R. F., & Ciarocco, N. J. (2005). Self-regulation and self-presentation: Regulatory resource depletion impairs impression management and effortful self-presentation depletes regulatory resources. *Journal of Personality and Social Psychology, 88,* 632–657. doi:10.1037/0022-3514.88.4.632

Vohs, K. D., Baumeister, R. F., Schmeichel, B. J., Twenge, J. M., Nelson, N. M., & Tice, D. M. (2008). Making choices impairs subsequent self-control: A limited-resource account of decision making, self-regulation, and active initiative. *Journal of Personality and Social Psychology, 94,* 883–898. doi:10.1037/0022-3514.94.5.883

Vohs, K. D., & Faber, R. J. (2007). Spent resources: Self-regulatory resource availability affects impulse buying. *Journal of Consumer Research, 33,* 537–547. doi:10.1086/510228

Vohs, K. D., & Heatherton, T. F. (2000). Self-regulatory failure: A resource-depletion approach. *Psychological Science, 11,* 249–254. doi:10.1111/1467-9280.00250

Wallace, H. M., & Baumeister, R. F. (2002). The effects of success versus failure feedback on self-control. *Self and Identity, 1,* 35–42. doi:10.1080/152988602317232786

Wallace, J. C., Edwards, B. D., Shull, A., & Finch, D. M. (2009). Examining the consequences in the tendency to suppress and reappraise emotions on task-related job performance. *Human Performance, 22,* 23–43. doi:10.1080/08959280802540957

Wan, E. W., & Sternthal, B. (2008). Regulating the effects of depletion through monitoring. *Personality and Social Psychology Bulletin, 34,* 32–46. doi:10.1177/0146167207306756

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54,* 1063–1070. doi:10.1037/0022-3514.54.6.1063

Webb, T. L., & Sheeran, P. (2003). Can implementation intentions help to overcome ego-depletion? *Journal of Experimental Social Psychology, 39,* 279–286. doi:10.1016/s0022–1031(02)00527-9

Wegner, D. M., Schneider, D. J., Carter, S. R., & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53,* 5–13. doi:10.1037/0022-3514.53.1.5

Westholm, A. (1987). Measurement error in causal analysis of panel data: Attenuated versus inflated relationships. *Quality and Quantity, 21,* 3–20. doi:10.1007/BF00221711

Wills, T. A., & Dishion, T. J. (2004). Temperament and adolescent substance use: A transactional analysis of emerging self-control. *Journal of Clinical Child and Adolescent Psychology, 33,* 69–81. doi:10.1207/S15374424JCCP3301_7

Wills, T. A., & Stoolmiller, M. (2002). The role of self-control in early escalation of substance use: A time-varying analysis. *Journal of Consulting and Clinical Psychology, 70,* 986–997. doi:10.1037/0022-006X.70.4.986

Wood, J. A. (2008). Methodology for dealing with duplicate study effects in a meta-analysis. *Organizational Research Methods, 11,* 79–95. doi:10.1177/1094428106296638

Wright, R. A. (2009). Sleep consistency as a mechanism for improving inhibitory system strength. *Stress and Health.* Advance online publication. doi:10.1002/smi.1302

Wright, R. A., Junious, T. R., Neal, C., Avello, A., Graham, C., Herrmann, L., Junious, S., . . . Walton, N. (2007). Mental fatigue influence on effort-related cardiovascular response: Difficulty effects and extension across cognitive performance domains. *Motivation and Emotion, 31,* 219–231. doi:10.1007/s11031-007-9066-9

Wright, R. A., Martin, R. E., & Bland, J. L. (2003). Energy resource depletion, task difficulty, and cardiovascular response to a mental arithmetic challenge. *Psychophysiology, 40,* 98–105. doi:10.1111/1469-8986.00010

Wright, R. A., Stewart, C. C., & Barnett, B. R. (2008). Mental fatigue influence on effort-related cardiovascular response: Extension across the regulatory (inhibitory)/non-regulatory performance dimension. *International Journal of Psychophysiology, 69,* 127–133. doi:10.1016/j.ijpsycho.2008.04.002

Received April 30, 2009
Revision received February 16, 2010
Accepted February 19, 2010 ■