Ego-depletion: Theory and Evidence

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Abstract

Self-control all too often fails. Despite people's best intentions and considerable negative outcomes, people often find themselves at the losing end of resisting temptation, combating urges, and changing their behavior. One reason for these failures may be that exerting self-control depletes a limited resource (ego-depletion) that is necessary for the success of self-control. Hence, after exerting self-control individuals are less able resist temptations, fight urges, or stop a behavior which results in a loss of self-control. This chapter reviews the evidence for this theory in a wide variety of domains and examines what behaviors appear to deplete ego strength and how depletion affects behavior. A comprehensive theory that examines how depletion operates is put forth and this theory is used to examine some factors that might moderate the depletion effect.

Keywords: self-control, ego-depletion, willpower, motivation

Introduction

As most people can attest, dieting, quitting smoking, controlling one's temper, and working instead of playing is not easy. In fact, it often feels quite difficult to avoid immediate, pressing, or easy behaviors in order to follow rules, get along with others or reach long-range goals. Moreover, such self-control efforts fail all too often. The point of the strength model of self-control (Muraven & Baumeister, 2000) is to better understand how people resist such temptations, understand why it fails (and why it succeeds) and what can be done to improve self-control.

Self-control is the process that enables organisms to override, inhibit or stop urges, emotions and moods, thoughts or behaviors in order to reach a long-term goal. These long-term goals can be personally set, such as losing weight or succeeding in school, or can be moral, interpersonal, or societal rules like not having premarital sex or not gossiping. Regardless of the type of goal, it typically requires the individual to forgo an immediate pleasure or desire in order to reach a more desired state in the future. That is, the organism is seeking to gain a larger but delayed reward over a smaller but more immediate reward. To do so, the organism must resist the temptation to take the immediate reward. Self-control is the process that allows this to happen (Kanfer & Karoly, 1972; Mischel, Shoda, & Rodriguez, 1989).

There are significant and important differences between self-control and self-regulation worthy of mention. Although these terms are sometimes used interchangeably, self-control is an important subset of self-regulation. Self-regulation is the process by which individuals pursue all goals, both short and long term. The process of self-regulation incorporates both conscious and unconscious process, such as breathing, eating, or driving to work every day. On the other hand, self-control is a deliberative, conscious, effortful, and resource intensive process of restraining an

impulse in order to reach a long-term goal or follow a rule. To the extent that a situation requires inhibition, it demands self-control. This distinction is important, because tasks that may seem effortful, like memorizing a list of words or solving simple arithmetic problems only require self-control to the extent that the individual has to override an impulse.

The ability to exert self-control is one of the critical features that differentiates humans from other organisms (Baumeister, 1998, 2005). Although other animals can exert self-control (for instance, squirrels burying nuts for the winter), it is clear that the self-control demands on human is much greater than the self-control demands on these other animals. Indeed, it has been argued (Sedikides & Skowronski, 1997) that the growth in the ability to exert self-control drove the development of human cognition, society, and the development of the self. Hence, understanding how self-control operates can give us insight into many critical features of the human experience.

Moreover, of course, understanding self-control has immense practical benefits as well. Self-control is critical to both preventing the initiation as well as the cessation of addictive behaviors (e.g., Brown, 1998; Wills, Sandy, & Yaeger, 2002). Other research has illustrated the importance of self-control in dieting (Heatherton, Striepe, & Wittenberg, 1998), overspending (Faber, 1992), relationship problems (Finkel & Campbell, 2001), violence (Stucke & Baumeister, 2006), and crime (Gottfredson & Hirschi, 1990). Given that many health problems can be linked to a lack of exercise, smoking, and poor eating habits, it is apparent that a lack of self-control is a major contributor to morbidity and mortality. Likewise, because many economic problems at both the personal and societal level follow from overspending, lack of consideration of future demands, and educational underachievement, a better understanding of how self-control operates is critical to our prosperity as well.

Ego Strength

An examination of past research on self-control (Muraven & Baumeister, 2000) suggested that self-control worsens over time. That is, after exerting self-control, subsequent attempts at self-control suffer. For instance, research on the effects of environmental stress (Glass, Singer, & Friedman, 1969) found that individuals who were exposed to uncontrollable or unpredictable noise subsequently performed more poorly on a test of persistence and frustration tolerance, after being moved to a quiet location, as compared to individuals who had been exposed to a controllable or predictable noise. These researchers argued that it was not the noise per se that affected performance, but rather the process of adapting and coping with the noise that depleted the individual so that he or she was less able to deal with future demands.

Such a depletion model can be contrasted with a constant resource or skill model. These models would predict that self-control should not be affected by previous demands, or may even get better as the individual warms up and gains knowledge of the tasks. The depletion model specifically predicts an after-effect of exerting self-control. That is, even after the initial self-control demand has been removed and a new situation introduced, there should be a carry over effect that leads to poorer self-control. Moreover, in order to be a unique prediction, this decline in performance should not arise from changes in mood, arousal, frustration, self-efficacy or other well-established psychological processes.

Extensive research has strongly suggested that the depletion model is the best fit for the observed data on self-control. In experimental studies, individuals who exert self-control perform more poorly on subsequent tests of self-control as compared to individuals who initially worked on a task that did not require self-control. For example, Muraven, Collins, and Nienhaus (2002) had social drinkers either suppress the thought of a white bear (a difficult thought inhibition

exercise Wegner, Schneider, Carter, & White, 1987) or solve addition problems. These tasks did not differ in perceived unpleasantness, effort, or difficulty; the only reported difference was the amount of self-control required. Subsequently, participants were given the chance to drink alcohol, with the caveat that afterwards they would take a driving simulator test and those who did well would win a prize. As compared to those who solved addition problems, individuals who had to suppress their thoughts drank more and become more intoxicated. This suggests that the exercise of suppressing thoughts lead to poorer control over alcohol intake subsequently. Indeed, participants' reports of the amount of self-control they exerted on the first task were related to the amount of alcohol they consumed. On the other hand, reports of mood, arousal, frustration, and displeasure were not related to the amount drank. This strongly suggests that the loss of control over alcohol intake is being driven by the amount of self-control exerted in the first part of the experiment.

The initial exertion of self-control only affects tasks that require self-control, further giving evidence to the specificity of the depletion model. For instance, people who strongly desire to drink alcohol must exert greater self-control not to drink than people who desire alcohol less. Hence, in the alcohol study (Muraven, et al., 2002), individuals who were not very tempted to drink were less affected by the initial exertion of self-control and drank less as compared to individuals who were higher in temptation. That is, the initial act of self-control reduced subsequent self-control performance, but did not lead to a general increase in alcohol intake (see also Muraven, Collins, Shiffman, & Paty, 2005). Additional research has further illustrated that difficult tasks that do not require self-control are unaffected by initial acts of self-control (Muraven, Shmueli, & Burkley, 2006).

Given these results, it has been suggested (e.g., Muraven & Baumeister, 2000) that exerting self-control may deplete a conceptual resource called *ego strength* (alternatively called *self-control strength*). In particular, this resource is critical to any and all attempts at self-control. It is not needed for any activities except self-control. This ego strength is limited and the amount of strength is critical to the success of self-control, so that more is better. The exertion of self-control depletes some of this resource, so that after engaging in self-control, the individual has less ego strength. People in this state are said to be *ego depleted* (or just depleted).

If indeed the level of strength is critical to the success of self-control and that the exertion of self-control depletes some of this resource, it follows that after exerting self-control, subsequent attempts at self-control may be more likely to fail. A good amount of research, from around the world, using a variety of methods, has found this pattern of results.

As noted above, the observed effects do not appear to be a product of mood or arousal, In most studies, mood and arousal has not been found to differ between participants who exerted self-control and those who did not (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven, Tice, & Baumeister, 1998). Likewise, mood and arousal was not related to final self-control performance. The same is true for more specific mood items, such as frustration, irritation, annoyance, boredom, or interest as well. Likewise, Wallace and Baumeister (2002) directly manipulated feedback about success and failure of the self-control efforts and also found no effect. In short, the decline in self-control performance after exerting self-control appears to be directly related to the amount of self-control exerted and cannot be easily explained by other, well-established psychological processes.

What Causes Depletion

Overall, and consistent with the definition of self-control given above, researchers have found that anytime an individual overrides, inhibits, stops, or changes a mood, urge, thought or behavior, it can lead to depletion and hence poorer self-control. For example, at the most basic level, Baumeister et al. (1998) showed that after resisting the temptation of eating chocolate chip cookies, participants quit working on a frustrating puzzle sooner than participants who had to resist eating radishes, which were not seen as tempting as the cookies. This suggests that overriding basic urges is depleting. Indeed, Muraven and Shmueli (2006) found a similar effect for alcohol and social drinkers, with the magnitude of the depletion effect being proportional to participants' self-reported desire to drink. Likewise, resisting the urge to eat cookies was more depleting to dieters than non-dieters, further suggesting that the strength of the impulse being inhibited may partially determine how depleting an activity is (Vohs & Heatherton, 2000).

Interpersonal. However, research has shown that many other behaviors are also depleting. One particular area of interest is the depleting nature of interpersonal interactions. For instance, Vohs, Baumeister and Ciarocco (2005) found that people who had to present themselves as competent and likeable to an audience motivated to believe otherwise were less able to regulate their emotions subsequently as compared to individuals who were asked to act naturally. Similarly, engaging in an interaction with a difficult, high-maintenance confederate lead to greater depletion than interacting with a more receptive person (Finkel, et al., 2006).

The difficulty of high-maintenance interactions seems to carry over to interracial interactions as well. Research has found that interracial interactions lead to poorer performance subsequently on the Stroop interference task as compared to same-race interactions (Richeson & Shelton, 2003; Richeson & Trawalter, 2005). This effect seems to exist for Black as well as

White individuals (Richeson, Trawalter, & Shelton, 2005). Being the target of prejudice and stigma also appears to be depleting, as individuals try to cope with the negative feelings and behaviors of being the target of stigma (Inzlicht, McKay, & Aronson, 2007). Even more powerfully, people who were ask to ostracize someone by not talking to them quit working on an unsolvable anagram task sooner than people who did not have to ostracize someone (Ciarocco, Sommer, & Baumeister, 2001). These studies suggest that self-presentation and maintaining (or ending) relationships are tasks that often require self-control.

Changing the self. Other activities that require the individual to change his or her behavior have also been found to be depleting. For instance, as would be expected, individuals who had to suppress their emotional reaction to a film designed to evoke sadness exhibited greater depletion than individuals who did not have to control their emotions (Muraven, et al., 1998). However, individuals who had to control their emotions and increase their sadness in response to a video clip of animals dying in an environmental disaster also exhibited greater depletion, as evidenced by less persistence on a frustrating task subsequently. This indicates that the direction of control is far less important than the exercise of control. Subsequent research replicated this effect with disgust (Schmeichel, Demaree, Robinson, & Pu, 2006), while indicating that these effects were not due to arousal. Hence, behavior change in all its forms appears to be depleting.

The act of making choices also seems to be depleting. In one study, participants were told that they were going to have to give a speech on issue that ran counter to their existing opinions. As compared to those who had no choice, those who were given a choice whether or not to make the speech persisted for less time on a difficult task afterwards compared to those who were not given a choice (Baumeister, et al., 1998). In later research, participants who made a series of

consumer decisions subsequently drank less of a bad tasting drink than those who rated the products but did not make a choice (Vohs, et al., 2008 see also Bruyneel, Dewitte, Vohs, & Warlop, 2006). This effect was even observed when making choices about pleasant outcomes and appears to be separate from implementing the choice.

Perhaps most intriguing is recent research that suggests that mentally simulating the self-control actions of others may also be depleting (Ackerman, Goldstein, Shapiro, & Bargh, 2009). Participants read a story about a waiter or waitress who was hungry but unable to eat the food that he or she served. Half the participants were told to simply read the story, whereas the other half were asked to imagine themselves as this waiter or waitress. The people who imagined themselves as the hungry but self-denying server reported being more willing to overpay for consumer products as compared to those who merely read the story. Although the exact mechanism for this effect remains unclear (see below for a further discussion of the nature of self-control depletion), the researchers argued that imagining oneself exerting self-control may both activate expectancies about depletion as well as actually require self-control. This further illustrates that although tasks that require self-control appear to deplete self-control resources, we must look beyond simple inhibition if we wish to understand how individuals exert executive control and guide their selves to long-term goals.

Consequences of Depletion

Understanding how a state of ego depletion affects subsequent performance may also help to illuminate the processes involved in self-control. First, consistent with definitions outlined above, the most clear cut consequence of depletion is a loss of self-control. This has been demonstrated in many different domains, some of which have already been described. For instance, after controlling their thoughts and not thinking about a white bear, participants had a

harder time not smiling, laughing or showing amusement at a humorous film as compared to individuals who did not control their thoughts (Muraven, et al., 1998). This effect has carried over to many different domains. For instance, depleted individuals (especially dieters) tend to eat more (Kahan, Polivy, & Herman, 2003; Vohs & Heatherton, 2000). Perhaps most artfully, Hofmann, Rauch, and Gawronski (2007 see also Friese, Hofmann & Wanke, 2008) found that the amount of candy individuals ate when not depleted was related to their self-report views toward food. However, when depleted, their implicit attitudes were a much better predictor of their consumption, which suggest that depletion reduced their ability to intentionally regulate their food intake (a similar study by Ostafin, Marlatt, and Greenwald (2008) found the same pattern with implicit and explicit measures of attitudes toward drinking and actual alcohol consumption). Consistent with that perspective, depletion has been found to affect the controlled components of stereotype based responses, but not the automatic component (Govorun & Payne, 2006).

Research on depletion has found similar patterns that depletion leads to poorer control over other behaviors of consequence as well. For instance, Muraven, Collins, and Nienhaus (2002) found that after controlling their thoughts, social drinkers consumed more alcohol despite incentives not to as compared to social drinkers who solved difficult and frustrating math problem that nonetheless did not require self-control. In a follow up, a field study of underage social drinkers who carried palm top computers for three weeks to report their self-control demands and drinking behavior found that on days that their self-control demands were higher than their average, these drinkers were more likely to drink to excess (Muraven, et al., 2005). The increased drinking was not apparently related to increased urges, greater negative affect, or a lack of desire to control drinking; instead it appeared to be related to an inability to regulate

alcohol intake. Depletion of ego strength has also been found to affect smoking behavior (Leeman, O'Malley, White, & McKee, 2010), regulation of sexual urges (Gailliot & Baumeister, 2007), and impulse spending (Vohs & Faber, 2007).

Although the predominant model is that depletion reduces individuals ability to inhibit urges (Govorun & Payne, 2006; Muraven & Shmueli, 2006; Ostafin, et al., 2008), there is also some evidence that depletion can also lead to stronger emotions and urges. For instance, Schmeichel, Harmon-Jones and Harmon-Jones, (2010) found that depletion increased individuals' approach motivation, so that they focused more on a reward-relevant stimulus than a reward-irrelevant stimulus. Ego depletion could therefore lead to poorer self-control by strengthening impulses, rather than undermining inhibition.

Broader Perspective. Less well investigated but important to understanding how depletion affects performance are studies on perception of time and passivity in depleted individuals. In particular, depletion apparently affects people's sense of the passage of time. Depleted individual estimated that more time had passed while exerting self-control than non-depleted individuals (Vohs & Schmeichel, 2003). This might contribute to the poorer self-control among depleted individuals, especially on persistence based tasks, as they may misjudge how long they have been acting on controlling themselves. More research is needed to better integrate these results into a more general theory of how self-control operates.

Similarly, Baumeister et al (1998) found that depleted individuals were more passive than non-depleted individuals. When quitting a boring task (watching an unchanging video of a blank wall) required participants to initiate a button push, depleted participants watched longer than non-depleted participants. On the other hand, when quitting was the passive option and continuing required a response, depleted participants quit sooner. The extent to which many of

the effects associated with depletion may spring from passivity and a general unwillingness to initiate an action is an unanswered question.

Interpersonal effects. There are clear interpersonal consequences to depletion as well. As expected from the decline in self-control performance, depleted people appear to be less likely to follow basic social norms, both prescriptive and descriptive (DeBono, Shmueli, & Muraven, 2011). For instance, depleted individuals are more likely to cheat (Muraven, Pogarsky, & Shmueli, 2006), lie, and steal (DeBono, et al., 2011). People whose self-control was depleted also engaged in more inappropriate social interactions, by talking too much, making too intimate interpersonal disclosures, or being arrogant (Vohs, et al., 2005). Clearly, being socially appropriate and following norms requires self-control and is affected by depletion.

However, the effects of depletion extend beyond simple impulsive control. For example, depleted individuals are also more easily persuaded. Burkley (2008) found that resisting a persuasive attempt leads to a pattern of self-control outcomes consistent with depletion. In later studies, he found that depleted individuals were more easily persuaded, especially by strong arguments. Wheeler, Brinol and Hermann (2007) found a similar pattern of results and persuasively argued that depleted individuals were more likely to agree with counter-attitudinal statements. Interestingly, they found that depleted and non-depleted individuals thought equally hard about the message, only depleted individuals were less likely to come up with counter-arguments to the message. These results suggest that depletion leads to passivity and agreement among people.

This passivity and general lack of ability to engage in counter-arguments may affect interpersonal perception as well. For example, individuals who were depleted rated African-American targets more negatively than European-American targets (Muraven, 2008b; Park,

Glaser, & Knowles, 2008). Depleted people may be less willing to override their stereotypes and less likely to think of reasons to do so (Devine, 1989). Research has also found that depletion makes people less helpful (DeWall, Baumeister, Gailliot, & Maner, 2008; Fennis, Janssen, & Vohs, 2009). Consistent with that reduced helpfulness, depleted people are less forgiving in their relationships: Individuals who were depleted were less likely to engage in accommodation (Yovetich & Rusbult, 1994) and therefore responded less constructively to the negative behavior of their partner (Finkel & Campbell, 2001). Depleted individuals lie more as compared to non-depleted people as well (Mead, Baumeister, Gino, Schweitzer, & Ariely, 2009), which can also damage relationships.

The effects of depletion further extend into aggressive behavior. It is likely that individuals have to learn to restrain aggressive urges in order to maintain harmonious relationships and therefore depletion of self-control resources may lead to a breakdown in this restraint. Indeed, depleted individuals have been found to react to provocations with greater aggression than non-depleted individuals (DeWall, Baumeister, Stillman, & Gailliot, 2007; Stucke & Baumeister, 2006). As compared to participants who were asked to not eat radishes, participants who were asked to not eat a donut placed in front of them slipped more hot sauce into the foods that were to be given to a participant who gave them negative feedback on an essay. When participants received neutral feedback on their essay, there were no differences between depleted and non-depleted conditions. This suggests that depletion was simply potentiating the aggressive responses and was not a direct cause of it.

Cognition. Depletion also appears to affects cognition. For instance, Schmeichel (2007) found that individuals who were depleted by regulating their emotions, controlling their attention, writing in a non-natural way or taking a working memory test performed more poorly

on subsequent tests of working memory span, reverse digit span, and response inhibition. Basic cognitive processes appear to be affected by depletion; the affected tests are considered to require substantial executive control and response inhibition. This decrease in mental efficiency apparently carries over to higher order functioning as well, as depleted individuals do worse on tests of logic and reasoning, reading comprehension, and a general test of fluid cognitive functioning than non-depleted individuals (Schmeichel, Vohs, & Baumeister, 2003; see also Shamosh & Gray, 2007). Depletion did not affect performance on a test of general knowledge or memorization and recall; tests that are presumed to require less higher order cognitive functioning.

As would be expected from the observed changes in cognition, depletion appears to affect decision making as well. In general, it appears that depleted individuals take greater risks, make poorer decisions, and fail to consider all alternatives as well as non-depleted individuals. For instance, Freeman and Muraven (2010) found that people who had to control their attention by ignoring information presented at the bottom of a video screen subsequently made more pumps on the Balloon Analogue Risk Task (Lejuez, et al., 2003), a measure of risk taking. The link between negative affect and risk taking was also found to be partially mediated by depletion—people's attempt to regulate their negative moods is depleting and this depletion leads to greater risk taking (Bruyneel, Dewitte, Franses, & Dekimpe, 2009). Depleted individuals also rely to a greater extent than non-depleted individuals on heuristics and fail to consider all options carefully in a consumer decision making tasks, which lead to a sub-optimal decision (Masicampo & Baumeister, 2008; Pocheptsova, Amir, Dhar, & Baumeister, 2009). In addition, it appears that depleted individuals are more likely to seek confirmatory information that is consistent with their existing viewpoints (Fischer, Greitemeyer, & Frey, 2008). Exerting self-control appears to reduce

the motivation to search for and process new information. This research is particularly notable for showing that the effects of depletion on decision making and information processing appears to be different from the effects observed from cognitive load, ego-threat, and mood.

This change in decision-making and risk-taking goes hand-in-hand with changes in self-perception. Depleted individuals are less optimistic about their abilities, have a lower sense of control, and are less optimistic about the future (Fischer, Greitemeyer, & Frey, 2007). Indeed, depleted individuals set lower standards for themselves and had less confidence in their ability to reach a goal than non-depleted individuals (DeBono & Muraven, 2009). Optimistic perspectives and positive illusions are apparently not automatic but instead require the individual to override doubts and negativity. These findings need to be better integrating into the idea of "automatic egotism" (Paulhus, Graf, & Van Selst, 1989), as well as the findings that depletion leads to greater heuristic processing and suggest that processes that consider egotism and self-enhancement automatic either need to be revised or depletion contributes to a decline in positive illusions in a novel way. In short, the underlying mechanism of maintaining illusions and why it is vulnerable to depletion requires attention.

Physiological Markers of Depletion. Finally, research on biological markers of effort and motivation similarly point to decreased cognitive control among depleted individuals. For example, Bray et al (2008) measured electromyographic (EMG) activation in depleted and non-depleted individuals as they isometrically squeezed a handgrip. Consistent with previous research (e.g,. Muraven, et al., 1998), depleted individuals were not able to hold the handgrip as long as non-depleted individuals. Moreover, depleted individuals had greater neuromuscular activation than non-depleted individuals, despite no differences in maximum strength. This indicates that the depletion is not the same as reduced motivation (which presumably would lead

to reduced maximal output) and also represents increased effort as if the person needs to overcome a motivational deficit.

A similar conclusion can be drawn from Segerstrom and Nes (2007), who found that resisting eating cookies lead to greater heart rate variability than resisting eating carrots and this heart rate variability correlated with persistence on a subsequent anagram task. This suggests that exerting self-control requires the mobilization of effort. The inability to maintain that effort over time may help explain how depletion arises. Indeed, that is the argument raised by Wright and colleagues (Wright, et al., 2007; Wright, Martin, & Bland, 2003; Wright, Stewart, & Barnett, 2008): high levels of fatigue require increased mobilization of effort (as indexed by cardiovascular output), but when the effort required is perceived to be too great then all efforts cease (Stewart, Wright, Azor Hui, & Simmons, 2009).

Intriguingly, research using electroencephalographic (EEG) methodology suggests that depletion can also be measured by changes in the event-related potential of error-related negativity (Inzlicht & Gutsell, 2007). Error-related negatively has been linked to pre-conscious error monitoring and correction and thus may be related to cognitive control over behavior. Individuals who had to control their emotions exhibited weaker error-related negativity signal while working on a Stroop task as compared to individuals in a control condition. Moreover, performance on the Stroop was related to magnitude of the error-related negativity signal, so that this neural signal mediated the link between initial self-control exertion and subsequent self-control performance. In short, depletion may affect neurological functioning and may be tied to specific changes in the neural system used for conflict monitoring.

How Depletion Operates

These biological markers of depletion provide some insight into how and why prior acts of self-control lead to subsequent self-control failure. As noted above, most research has been founded on the idea that depletion reduces individuals' ability to inhibit behaviors. The exact process underlying that effect is still an area of active investigation, with two main theoretical lines. The first focuses on a motivation or expectancy account, which suggests that self-control fails because individuals hold certain beliefs about how self-control should operate. The biological account, on the other hand, suggests that ego depletion is more than a metaphor and actually represents the loss of a crucial biological resources needed for the success of self-control. Ultimately, as with many dichotomies, the truth may lie in the integration of these accounts.

Expectancies. Arguments for the expectancy account for the depletion effect suggest that individuals hold beliefs that self-control is limited and therefore after exerting self-control, they expect to fail in subsequent attempts at self-control. For instance, individuals who felt that self-control was limited and depletes a limited resource were more affected by the initial self-control demand than individuals who did not subscribe to such a belief (e.g., Job, Dweck, & Walton, 2010; Martijn, Tenbuelt, Merckelbach, Dreezens, & de Vries, 2002). The researchers argued that this suggests that the depletion effect springs from expectancies about the nature of self-control. Indeed, in subsequent research, they found that individuals who were not paying attention to their self-control efforts exhibited less of a decline in self-control than individuals who were not distracted (Alberts, Martijn, Nievelstein, Jansen, & de Vries, 2008). This leads credence to the idea that some of the effects of exerting self-control on subsequent self-control performance are psychologically mediated and based on expectations of self-control demands.

Similarly, Clarkson et al (2010) found that people's perceived levels of depletion predicted their performance on tasks that required self-control. Depleted (or not depleted) individuals were given (false) feedback about this depleting task that lead them to attribute their resources to external or internal sources. For instance, participants crossed off the letter 'e' that is next to or one away from another vowel (those in the control condition simply crossed off all e's). Crossed with this, participants were told that the color of the paper could either "*exhaust and deplete* their ability to attend to information" or "*energize and replenish* one's ability to attend to information" (p.33, italics in original). In the low depletion condition, the replenishment feedback led to greater persistence on a subsequent task than the depletion feedback. This pattern was reversed in the high depletion condition. In short, people's perception of their level of self-control resource was a predictor of their subsequent self-control performance regardless of their actual level of resource.

In summary, the expectancy account of depletion suggests that people fail at self-control because they believe it should fail. Most people apparently subscribe to the belief that self-control is a limited resource and after exerting self-control this belief is typically activated, which leads to poorer self-control subsequently. This may explain many of the outcomes described above, although it may have greater difficulty in explaining situations in which the exertion or need for self-control is not apparent (e.g., cognitive performance) nor does it explain why seemingly difficult tasks (Muraven, et al., 1998), like solving math problems does not lead to a decline in self-control performance. This model suggests that people have a finely attuned sense of what requires self-control and what does not.

Biology. There are also some persuasive arguments that the effects of depletion may be biologically mediated. In particular, there is evidence that levels of glucose, particularly in the

brain, may also explain the decline in self-control performance after exerting self-control. Glucose is the primary source of energy for all brain activity and therefore a decline in glucose may negatively affect executive functioning (Siesjö, 1978). For instance, low levels of glucose are related to poorer cognitive functioning in both rats (McNay, McCarty, & Gold, 2001) and humans (Benton, 1990; Martin & Benton, 1999). More recent research has directly linked glucose to self-control, as individuals with lower levels of blood glucose have been found to engage in greater discounting of the future. Consistent with this argument, the ingestion of sugar negates this drop in self-control (Wang & Dvorak, 2010).

Like the hypothesized ego strength, glucose can be consumed faster than it can be replenished under heavy cognitive demands. Hence, exerting self-control may deplete glucose, a vital fuel for cognitive efforts. Indeed, recent research found that dogs who were required to follow rules and resist a temptation had lower levels of glucose than dogs who were not required to be obedient (Miller, Pattison, DeWall, Rayburn-Reeves, & Zentall, 2010). A similar effect has been found in humans after engaging in tasks that likely require self-control (Fairclough & Houston, 2004; Gailliot, Baumeister, et al., 2007). For example, Gailliot et al (2007) reported that individuals who were instructed to deliberately ignore words at the bottom of a video clip suffered a greater drop in blood glucose levels from baseline than individuals who saw the same clip but did not have to ignore the words. This change in glucose correlated with subsequent self-control performance. Later experiments showed that this decline in self-control performance after exerting self-control could be negated, however, by the ingestion of glucose (in the form of orange juice). Given that these patterns closely mirror the predictions of ego strength model, it seems likely that some of the observed effects are being driven by the depletion of glucose in the brain. Sugar only improves the performance of depleted individuals and has no effect on non-

depleted individuals, which suggests that depletion may be related to reduced levels of sugar (Masicampo & Baumeister, 2008; also found in dogs by Miller, et al., 2010). This study also showed that the ingestion of a non-nutritive sugar substitute (Splenda) had no effect on depletion, which further indicates that the effects are not simply due to expectations or merely drinking a pleasant drink. Denson et al (2010) replicated these findings in a study that looked at the effects of ego depletion on aggression.

In short, there are persuasive arguments that exerting self-control may require and deplete glucose and this drop in glucose may drive the decline in self-control performance. This helps to explain the specificity of the depletion on self-control and executive control and may fit well with the physiological effects associated with depletion. However, changes in glucose cannot be easily integrated with the fact that changes in expectancy for self-control apparently also lead to changes in self-control performance. The biological account also leads little room for motivation in depletion.

Integration: Effects of Motivation and Conservation

Even if the depletion of glucose in the brain is a contributor to poorer self-control outcomes, the final result must be psychologically mediated. It is very unlikely that exerting self-control depletes all available glucose so that self-control becomes impossible. Indeed, except in very rare and unusual circumstances, most individuals who fail at self-control do not lose control over all actions and become completely animalistic. Individuals who exert self-control on a laboratory task and hence exhibit poorer self-control subsequently do not urinate on themselves but instead ask to be excused to go to the bathroom. Thus, a complete model of depletion needs to explain both the specificity of depletion to self-control and how it can be moderated by motivation.

Motivation. For instance, Muraven, Pogarsky and Shmueli (2006) found that depleted individuals were more likely to lie and cheat on a laboratory task than non-depleted individuals. However, this was only true when the perceived probability of getting caught was low. When the odds of the experimenter discovering the deviance was high, depleted individuals were no more likely to cheat than non-depleted individuals. Likewise, Wan and Sternthal (2008) found that depleted individuals who were encouraged to engage in self-monitoring by being given a clock while working on a persistence task worked as long as non-depleted individuals. As self-monitoring has been found to increase motivation and goal adherence (Carver & Scheier, 1998), it is likely that this self-monitoring feedback lead to increased motivation that negated the effects of depletion.

Even more directly, depleted individuals who were given an incentive to exert self-control, in the form of either money, social acceptance, or moral expectations, performed just as well on a subsequent self-control task as participants who were not depleted (Muraven & Slessareva, 2003). For instance, when paid a cent per cup, individual who had to suppress their emotional reaction to a humorous video clip drank less of a vinegar flavored drink as compared to individuals who simply watched the video with no instructions to control their emotional reaction. On the other hand, when the incentive for drinking was high (25 cents per cup), individuals who had to suppress their emotional reaction drank just as much of the sour drink as individuals who did not suppress their reaction.

The motivation can apparently be unconsciously activated as well. For instance, Alberts et al (2007) found that depleted individuals who were given primes related to persistence (either by unscrambling sentences with persistence words in them or seeing a screensaver with motivational images) performed better than depleted individuals not given these primes.

Likewise, thinking of good self-control exemplars lead to better self-control among depleted individuals than thinking of a neutral example (Martijn, et al., 2007). Even the mere symbolic presence of family members appears to lead to better self-control in depleted individuals (Stillman, Tice, Fincham, & Lambert, 2009).

The results indicate that people can overcome depletion if sufficiently motivated. Thus, a reduction in glucose levels may increase the likelihood of self-control failure, but only when the individual is insufficiently motivated. Given that motivation plays a critical role in contributing to self-control failures, the question then arises why past self-control efforts matter at all. Further research, based on the idea of the conservation of limited resources, suggests they do.

Conservation. In particular, if self-control requires glucose or other limited resources, it makes sense to use this resource as wisely as possibly. People should be judicious in how and when they exert self-control, so they can have resources for future demands or emergencies. This self-control resource can be compared to other limited resources, such as money. The sensible person keeps a cushion of money in his or her checking account, to pay for unexpected events. Moreover, consistent with prospect theory (Tversky & Kahneman, 1981), the less money one has, the more the remaining money should be valued.

Analogously, individuals should be concerned with conserving ego strength to the extent that it is perceived to be a limited resource. Depletion of this resource, through the exercise of self-control, should heighten this desire to conserve the remaining resource. It then follows that individuals who are motivated to conserve ego strength may be less likely to exert self-control, which therefore leads to poorer self-control performance. This may explain why depleted individuals typically perform more poorly on tasks that matter less to them, but perform just as well as non-depleted people on important, self-relevant, or external motivated tasks.

Muraven, Shmueli and Burkley (2006; see replication by Tyler & Burns, 2009) tested this idea by manipulating participants' expectations for the future. If people expect to exert self-control in the future, their motivation to conserve should be increased; this should be especially likely if their ego strength was already depleted. In one experiment, participants first had to control a well-learned pattern by typing a paragraph without hitting the "e" key (participants in the control condition just typed the paragraph as they saw it). They were then told that they would take two more tests. The first was a Stroop test, where they would have to state the font color of word. After that, they would have to solve anagrams that were either described as requiring them to "think hard" (low self-control) or "override impulses" (high self-control). Participants who had to exert self-control in the first part of the experiment and who expected to exert self-control in the future exhibited poorer self-control on the Stroop task as compared to those who did not exert self-control in the past or those who did not expect to exert self-control in the future.

Further evidence for conservation came from participants' actual performance on the final task. In particular, how long they persisted on difficult and frustrating anagrams before quitting. There was a negative correlation between Stroop performance and time spent on the anagrams, suggesting a trade off in resource use. That is, worse performance on the Stroop (which would suggest conserving) was associated with greater self-control on the anagram. Janssen, Fennis, and Pruyn (2010) found a similar effect: Depleted individuals who were warned about an upcoming persuasive attempt conserved strength and hence generated better counterarguments and resisted the compliance more than depleted individual who were not forewarned.

In short, people appear to manage their self-control resources based on their past efforts and future demands. The desire to conserve strength can help both explain the specificity of the

depletion effect to self-control and how motivation and expectancies can moderate this effect. The desire to conserve should not be necessarily interpreted as a conscious process, however. There is very limited evidence that people are aware of their self-control states; instead, there appears to be a complex process of unconscious weighing of alternatives. Further work is necessary to understand how these motivational processes work together to lead to self-control failures.

Moderators of Depletion

This conservation model of self-control failure points the way toward understanding when self-control is more likely to fail and when it is less likely. Hence, there may be processes that moderate the link between depletion and self-control failure. That is, there are some situations in which the link between depletion of ego strength and final self-control performance is weakened (or strengthened). These moderators may give some further insight into how depletion works and some limitation to our self-control.

Automatization. Intuitively, anything that reduces the self-control demand on a behavior should reduce how depleting it is. Indeed, as noted above, there is a relationship between how much self-control a task required and the subsequent decline in self-control performance (e.g., Muraven, et al., 2002). Hence, it was suggested that implementation intentions (Gollwitzer & Brandstätter, 1997) should help in the elimination of ego depletion. Implementation intentions help automatize behaviors by creating a clear link between when, where, and how an individual will strive for a goal. This helps reduce the self-control demand of a situation, as it forges an association between a cue and a response, thereby reducing the need for conscious control.

In an examination of the effects of implementation intentions on depletion, participants who created implementation intentions for the Stroop task (e.g., “As soon as I see the word I will

ignore its meaning") subsequently persisted longer on a frustrating task than individuals who did the same Stroop task without the benefit of creating an implementation intention (Webb & Sheeran, 2003). In a second study, the opposite of this effect was found: depleted individuals who created implementation intentions for a Stroop task read the list of words faster than depleted individuals who did not create a plan. Making a plan apparently reduced the resources required for self-control, so that tasks were less depleting and less affected by depletion.

Rest and replenishment. There clearly must be some way to recover lost resources. However, to date, this topic has not received extensive attention. It is likely that rest from exerting self-control is one way in which resources are recovered. For instance, Shiffman et al (1996) reported that although the urge to smoke is strongest in the morning, most lapses occur in the evening. This is consistent with the idea that in the morning people are rested and therefore have the strength to deal with their urges. Later in the day, however, more strength has been depleted and therefore their ability to resist the temptation to smoke has been diminished. Research that focused more directly on depletion on a smaller scale found a similar pattern (Tyler & Burns, 2008). Participants who had a 10 minute break between the first self-control task and the subsequence measure performed better than participants who did not have the break and equal to non-depleted individuals. A similar effect was found for participants who were induced into relaxing between tasks.

It may be possible to accelerate this recovery process through positive affect (Tice, Baumeister, Shmueli, & Muraven, 2007). Participants who were depleted by resisting the temptation of cookies and candy failed to persist as long on a frustrating task as compared to those who had to resist the temptation of eating radishes. However, if they watched a comedy between resisting the food and persisting, those who could not eat the cookies persisted just as

long as those who could not eat the radishes. The general conclusion is that positive experiences negate the effects of ego-depletion and the effects are not driven by arousal, distraction, and are specific to tasks that require self-control. The researchers argued that positive affect may help to replenish lost ego strength. It may do this directly, by serving as a resource, or it may just increase motivation or willingness to exert self-control. That is, it might be like giving coffee to a tired person—it gets them going for a while, but a crash is inevitable, or it might be like getting a good night's sleep. Further empirical research is required to differentiate between these accounts.

Finally, affirming the self (Steele, 1988) appears to help negate the effects of depletion (Schmeichel & Vohs, 2009). Individuals who were depleted by having to write a story without using any words containing the letter a or n removed their hand from ice water sooner than participants who wrote a story without such restrictions. However, if the depleted individuals were given the chance to rank 11 values and personal characteristics in order of personal importance, this effect disappeared: depleted individual held their hand in the water as long as non-depleted individuals. The effects were not related to changes in mood. Instead, the researchers argued that the self-affirmation lead individuals to consider abstract, long-range outcomes, which improved their self-control performance.

Autonomy. Perhaps related to these replenishment finding is research on the effects of autonomy support on depletion. The idea of autonomy support is that some situations encourage and are more supportive of behaviors that are intrinsic and self-driven, whereas others take that feeling away (Ryan & Deci, 2000). Time pressures, external rewards, and authority figures cause individuals to feel compelled to act, which in turn diminishes the extent to which the behavior feels intrinsic, genuine, and self-motivated.

Several studies have clearly shown self-control that feels compelled by the situation is much more depleting than self-control that feels more autonomously driven. For instance, Moller, Deci and Ryan (2006) gave some participants a choice between several different activities and then measured their self-control performance. They found that people given such a choice without any constraints exhibited better self-control subsequently as compared to people who were told that although they were free to choose, the experimenter really needed them to select a particular activity. This effect was found to be mediated by feelings of self-determination, but not mood.

People's own reasons for exerting self-control can have a similar effect. A plate of cookies was placed in front of participants, with the instructions to please not eat them unless absolutely necessary (Muraven, 2008a). They were then asked why they did not eat the cookies, to measure their feelings of self-determination. People who did not eat the cookies for more self-determined reasons (e.g., because it matters to me) exhibited better self-control by squeezing a handgrip longer, as compared to those who did not eat the cookies for more extrinsic reasons (e.g., the experimenter would get mad at me).

These results suggest that autonomously driven self-control is less depleting than self-control that is compelled by others or the situation. Further research suggested that this outcome may be driven by the replenishment effect described above. Participants instructed to avoid thinking about a white bear by a warm, open, and friendly experimenter who tried to engage participants as a vital contributor to the research project subsequently exhibited better self-control on a dependent measure of self-control than participants who were instructed by a more distant and cold experiment who treated participants like a "cog in the machine" (Muraven, Gagné, & Rosman, 2008; see also Muraven, Rosman, & Gagné, 2007). The participants in the

autonomy supportive condition had greater feelings of subjective vitality (Nix, Ryan, Manly, & Deci, 1999; Ryan & Frederick, 1997), a positive state of aliveness and energy that arises from acting in self-actualizing ways. These feelings of vitality mediated the link between experimental condition and self-control outcomes, so that the reason why people in the autonomy supportive condition exhibited less depletion was because they felt more vital. This is consistent with the replenishment idea, and further suggests that self-control behaviors that are associated with positive states should lead to less depletion of strength.

Building Strength

The research described above focuses primarily on the short-term effects of exerting self-control. A quick summary would suggest that people act as if self-control is a muscle, which gets fatigued with use. This fatigue effect is moderated by several different processes, and may be related to glucose levels in the brain, as well as beliefs that self-control is limited.

Muscles do get fatigue through work, much like the effects observed with self-control. However, muscles also get stronger, providing they are worked hard and frequently and rest is taken. Is the same true with self-control? That is, can people strengthen their self-control muscle by exercising their self-control? The evidence suggests that they can.

In the first study on this process, Muraven, Tice, and Baumeister (1999) asked participants to practice self-control by either maintaining a diary of food intake, keeping good posture, or regulating their moods to avoid negative emotions as much as possible. The control group had no special instructions and went about their daily life. Participants' handgrip squeezing time (relative to their baseline) after engaging self-control was assessed at the start of the study and again after they had practiced their assigned task for two weeks. Those who practiced self-control were less affected by the depleting task as compared to those who did not

practice self-control and the effects were stronger for participants who practiced more. This is evidence that practicing self-control can increase self-control endurance, so that people are less affected by depletion. Put another way, practicing self-control increased their stamina, so that they were able to exert self-control even when already fatigued.

Comparably, research by Oaten and colleagues (Oaten & Cheng, 2006a, 2006b, 2007), as well as Gailliot and colleagues (Gailliot, Plant, Butz, & Baumeister, 2007) found that practicing self-control can also increase self-control power. That is, even in non-depleted states, participants who practiced self-control exhibited better self-control outcomes. This is the equivalent of strength, so that after practicing self-control individuals could overcome more powerful impulses. For instance, in Hui et al (2009), participants either engaged in a strong training program (work on the Stroop task for 5 minutes twice day for two weeks and rinse with a mouthwash that produces a powerful burning sensation) or a weak training program (no conflict between ink color and word; diluted mouthwash). At the end of this training participants returned to the laboratory and engaged in several tasks that required self-control. As compared to those who had no training or those who had the weak training, those who underwent the strong training held their hand in ice water significantly longer. They also performed better on a visual search task that requires regulating attention and concentration, had better dental care (based on amount of dental floss and toothpaste used) and reported better health related behaviors.

Recent research by Muraven (2010a, 2010b) has further extended these findings to make it clear that the effects of practicing self-control are above and beyond any effects expected from expectation or self-efficacy. Smokers who were interested in quitting were assigned one of four tasks to practice for two weeks before beginning a cessation attempt. Two of these conditions required self-control (avoid eating sweets and squeeze a handgrip exercise for as long as possible

twice a day) and two did not (maintain a diary of any time they exerted self-control and work on difficult math problems). Consistent with previous research, smokers who practiced tasks that required self-control remained abstinent longer than smokers who practiced tasks that did not require self-control. Moreover, the control tasks evoked awareness of self-control, increased self-monitoring, increased self-efficacy, and participants expected these tasks to be helpful in their cessation attempt. This means that the effects of practicing self-control on subsequent improvements in self-control are above and separate from the smokers' expectation that it should help them quit smoking, improvements in self-efficacy, or greater self-monitoring. Put another way, practicing self-control has a direct effect on subsequent self-control performance.

Conclusion

The depletion model of self-control suggests that self-control is bounded by a limited resource that gets depleted with use. A growing body of research, in a variety of domains, suggests that after exerting self-control, individuals have greater difficulty resisting subsequent self-control demands as this resource is taxed. Although this resource may be biologically mediated (possibly glucose), the process of self-control failure is also psychologically driven, as individuals use social cues in motivating themselves to exert self-control. It appears that the process of depletion can be moderated by individuals' mood, feelings toward the self-control activity, and ability to recover lost resources.

The model suggests that managing this resource is vital to the success of self-control. Given the wide range of behaviors that have been shown to be affected by depletion and depleting in themselves, including high order cognition, controlling aggression, getting along with others, regulating moods, and resisting the temptations of sex, food, and drugs, clearly a better idea of how self-control operates is critical at the personal and societal level.

Future Directions

Indeed, the findings on building strength and how self-control is moderated by motivation may point the way for further research. A better understanding of how processes underlying the improvements observed after practicing self-control is critical to both advancing theory and crafting the best interventions. In particular, the process of building strength should probably be tied in the conservation model that links the biological and motivation accounts of strength. Such a complete theory should help in predicting which tasks will lead to the most improvement in self-control, how long they should be practiced, and how often.

The conservation model also would benefit from additional research to refine its predictions. For instance, it is not clear how people judge their future and past self-control demands, as well as introspect their levels of resource. This is an area ripe for investigation, as it may illuminate how people process information critical to self-control, which would lead to more powerful theories of self-control. Such a model of conservation might also better explain the processes underlying the replenishment effect of positive affect, as well as the findings that autonomously driven self-control is less depleting than self-control that feels compelled.

The findings that depletion leads to greater passivity and changes in time estimation likely need to be better integrated into the literature as well. These results may help to explain a wide variety of outcomes and may present an opportunity for creating a more unified theory of depletion. Ultimately, it may be possible to link these findings to changes in brain operation, for example, whether glucose is connected to passivity and a lack of motivation.

In the end, a comprehensive theory of self-control may be of profound practical and theoretical importance. Many of the problems facing people and society arise from or could be addressed from improvements in self-control. Moreover, because self-control is so critical to

what makes us human and enables us to reach our full-potential, a theory of self-control may help in explaining other important aspects of the human condition.

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