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Self-Control as Limited Resource: Regulatory Depletion Patterns

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If self-regulation conforms to an energy or strength model, then self-control should be impaired by prior exertion. In Study 1, trying to regulate one's emotional response to an upsetting movie was followed by a decrease in physical stamina. In Study 2, suppressing forbidden thoughts led to a subsequent tendency to give up quickly on unsolvable anagrams. In Study 3, suppressing thoughts impaired subsequent efforts to control the expression of amusement and enjoyment. In Study 4, autobiographical accounts of successful versus failed emotional control linked prior regulatory demands and fatigue to self-regulatory failure. A strength model of self-regulation fits the data better than activation, priming, skill, or constant capacity models of self-regulation.

The capacity of the human organism to override, interrupt, and otherwise alter its own responses is one of the most dramatic and impressive functions of human selfhood, with broad implications for a wide range of behavior patterns (Carver & Scheier, 1981; Wegner & Pennebaker, 1993). For example, self-regulation has been associated with crime and criminal behavior (Gottfredson & Hirschi, 1990), smoking (Russell, 1971), and dieting (Herman & Polivy, 1975). Men with better self-control are less likely to become divorced (Kelly & Conley, 1987). Children who are better at delaying gratification tend to be calmer, to resist frustration better, to be less irritable and aggressive, to concentrate better, and to get higher grades in school than children who are less able to delay gratification (Funder & Block, 1989; Funder, Block, & Block, 1983). Additionally, children who were better able to control themselves could deal with stress better in adolescence and had higher SAT scores when applying to college (Shoda, Mischel, & Peake, 1990). It is clear that self-control is related to success in many aspects of life.

Furthermore, the failure of self-control has immense personal and societal repercussions (Baumeister, Heatherton, & Tice, 1994). Breakdowns in self-control are linked with depression (Beck, 1976; Pyszczynski, Holt, & Greenberg, 1987; Wenzlaff, Wegner, & Roper, 1988), obsessive or ruminative thoughts (Martin & Tesser, 1989; Wegner, Schneider, Carter, & White, 1987), and aggression (Baumeister, 1997; Gottfredson & Hirschi, 1990; Tice & Baumeister, 1993; Zillman, 1993). Baumeister et al. (1994) concluded that many of the problems facing both individuals and society today, ranging from unprotected sexual behavior to addiction to school underachievement, involve regulatory failure. Therefore a deeper understanding of how, why, and when self-control breaks down is highly desirable.

The purpose of this article is to examine one central reason why self-control may fail. We propose that people have a limited capacity for self-regulation, akin to having a limited supply of strength or energy. One central prediction of any such model is that exertion will be followed by a period of diminished capacity. Therefore, when people engage in self-regulation, they should show subsequent decrements on other tasks that might require self-regulation. The present investigation was specifically concerned with testing this hypothesis of *regulatory depletion.*

Strength and Depletion

Because our emphasis was on the strength model, we shall develop it in most detail. In this view, self-regulation is the attempt to control or alter one's own responses. Because many responses have a motivational strength (e.g., Hull, 1943), the capacity for self-regulation requires strength to overcome them. Thus, in the standard example of dieting or resisting temptation in general, the person must exert strong self-control to prevent himself or herself from carrying out a strong but forbidden impulse. The strength model of self-regulation is implicit in the traditional concept of *willpower,* and indeed recent theorists such as Mischel (1996) have proposed that the concept of willpower needs to be revived to account for delay of gratification and similar patterns of self-regulation.

There are some indications that self-regulation involves exertion, consistent with a strength model. Self-regulation results in physiological arousal, which seems to imply effort and exertion. For example, regulating one's emotions, due to either stable individual differences in emotional expression or specific instructions to control one's emotions, is arousing (Adelmann & Zajonc, 1989; Gross & Levenson, 1993; Pennebaker, 1985). Inhibiting one's facial expression of emotion or pain also results in increased arousal (Lanzetta & Kleck, 1970; Notarius, Wemple, Ingraham, Burns, & Kollar, 1982). Additionally, research has shown that holding anger in or regulating its expression leads to physiological arousal, such as increased blood pressure,

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a faster pulse, and decreased skin conductance (Funkenstein, King, & Drolette, 1954; Haynes, Feinlieb, & Kannel, 1980; Holroyd & Gorkin, 1983; MacDougall, Dembroski, & Krantz, 1981; Schalling, 1985).

The arousing effects of self-regulation are not limited to just regulating emotions. Attempts to regulate one's attention also result in physiological changes (Kahneman, 1973; Pribram & McGuinness, 1975). Wegner, Shortt, Blake, and Page (1990) found that arousal increases when one engages in thought suppression. In their study, physiological arousal was higher in participants told not to think about sex than in participants who thought about sex. Similarly, there is evidence that lying is often accompanied by the suppression of nonverbal behavior, presumably so as not to give away clues that can reveal the truth, and this self-regulatory exertion leads to increased physiological arousal during the lie (Pennebaker & Chew, 1985). The overall patterns of results indicate that self-regulation results in both behavioral and physiological changes. These changes suggest that self-regulation is an effortful process.

A strength model entails that the capacity for self-regulation is a limited resource. At any moment there is a fixed amount of regulatory capacity available for self-regulation, and so regulating one response may result in poorer regulation of a concurrent response. For example, research by Gilbert, Krull, & Pelham (1988) showed that deliberate attempts at self-control reduced performance on other tasks that were being performed simultaneously. Participants who actively tried to control their attention and to ignore meaningless, irrelevant stimuli performed worse on a concurrent task than participants who saw the same meaningless stimuli but did not actively try to ignore them. Limited attention alone cannot explain these results, because participants in both conditions saw (and ignored) the same meaningless stimuli. Instead, differences in performance on the main task must be due to differences between effortful and less effortful self-control. One can conclude that effortfully controlling oneself consumes a limited resource that reduces the amount of this resource available for other tasks, resulting in poorer performance on these tasks. This resource may be the capacity for self-regulation.

Where a strength model differs from other limited capacity models is that exertion leads to fatigue. In other words, the depletion of regulatory capacity is not just concurrent but rather continues for a period of time. The resource is limited in such a way that expending it is followed by a period of scarcity, until it builds up again. This is roughly the difference between attention and muscular strength: Both may be limited, but one's quantity of available attention returns to full as soon as current demands on it cease, whereas muscular exertion is followed by a period of reduced capacity. Hence after self-regulation in one sphere, self-regulation in other domains may not be as effective, because regulatory capacity is reduced. Eventually, with sufficient rest, regulatory strength should return to its previous level, but in the short term the person should have a reduced capacity for self-regulation.[1]

An additional assumption of the strength model is that all self-regulation tasks draw on the same resource. In other words, there is a single capacity or dimension underlying the wide variety of self-regulatory patterns. Consistent with this hypothesis, prior research has found that self-regulatory capacity consists of a single dimension, which includes both traditional measures of self-control (i.e., delay of gratification) and endurance of physical discomfort (Eysenck, 1960). Very early factor analysts also found that tests of mental and physical endurance loaded on a single factor labeled *willpower,* which seemingly means regulatory strength (Rethlingshafer, 1942; Thornton, 1939). Such findings suggest that almost any self-regulatory exertion will be able to deplete the capacity for any other.

Thus, a strength model of self-regulation depends on three points. First, the process of self-regulation consumes some resource, leaving it depleted afterward. Second, success at self-regulation depends on the availability of this resource, and possibly self-regulation may be a linear function of this resource. Third, all forms of self-regulation require some such resource, and indeed they may all draw on the same resource. These assumptions furnish the relevant prediction that an act of self-regulation will be followed by poorer self-regulation even in other, quite different, spheres.

Competing Models and Predictions

The strength model of self-regulatory capacity can be contrasted with other possible models that would make different predictions regarding consecutive acts of self-regulation. These models differ with regard to what they emphasize as the essential nature of self-control in the short term.

First, self-regulation might be a knowledge structure, such as if self-regulation consists primarily of a master schema containing information about how to control the self and manage its responses. If this view is correct, then consecutive acts should conform to the well-established patterns of priming or spreading activation (Bargh & Pietromonaco, 1982; Higgins & King, 1981; Wyer & Srull, 1980). That is, an act of self-regulation might prime or increase the accessibility of self-regulation, and so an initial act of self-regulation would lead to better self-regulation subsequently. If self-regulation operates like a schema or other knowledge structure, then activating it should facilitate subsequent self-regulation.

A second alternative would view self-regulation as a skill. In this view, self-regulation is essentially an overlearned capacity to control the self. Although skill is built up gradually with practice, it remains essentially constant over consecutive trials. Hence the skill model would predict that one act of self-regulation would have no effect on how well one regulates oneself immediately afterward. (At most, there might be a slight warm-up effect as is found with some athletic skills.) Put another way, one's success at self-regulation would be unaffected by a previous act of self-control.

Thus, these two views of the nature of self-regulation make quite different predictions from a strength model about how an initial act of self-regulation should affect the person's efforts to regulate the self immediately afterward. The schema, skill,

[1] It is important to note that this depletion of regulatory strength is a short-term effect only; after a period of rest it should return to its previous level. Indeed, much like muscular strength, it is possible that after repeated exertions the overall capacity for self-regulation may increase. This means that self-control in all domains may get easier after repeated attempts at self-control in one specific domain.

and strength models predict facilitation, no change, or impairment, respectively.

One other possible view is that self-regulation is a limited but constant capacity. In this view, concurrent efforts at self-control will impair each other insofar as both draw on the same resource, but the resource used for one act of self-control would be fully available for a new task as soon as the first is finished. Hence there should be no effect on consecutive acts of self-regulation—only on simultaneous acts.

Present Research

The present series of studies was designed to test the competing predictions about consecutive acts of self-regulation. A strength model of self-regulation would predict that people's performance would be poorer on the second task, because their strength was depleted by the initial exertion. Other views of self-regulation might predict no effect or even an improvement on the second task.

We conducted three laboratory experiments in which we had people engage in self-regulation and then perform a subsequent, seemingly unrelated task that also required self-regulation. Specifically, the first study was designed to show that an exercise of affect regulation would reduce subsequent performance on a muscular endurance task. The second experiment was designed to show that a thought suppression exercise would reduce subsequent persistence on a frustrating anagrams task. The third experiment was designed to rule out potential alternative explanations and provide converging evidence with a quite different method. In this experiment, participants who controlled their thoughts should be less able to control their emotional expression while watching a funny video. Last, to increase external validity and to expand the methodological breadth of the evidence, we conducted a study using autobiographical narratives. We had participants write first-person accounts of events in which they could versus could not control their emotions. We then looked for patterns of differences between these two types of stories, such as other regulatory demands, as well as indices of a depleted level of regulatory capacity (tiredness).

Study 1

Study 1 provided the first experimental test of the limited resource model. By inducing participants to engage in an initial exercise of self-regulation, we would be able to learn whether subsequent self-regulation would be impaired, as the strength model predicted. The study consisted of two main parts: (a) the manipulation of regulatory exertion, during which participants self-regulated (or did not regulate) their emotional response to an upsetting movie, and (b) the dependent measure, which was the measure of regulatory performance. Based on the limited resource model, we predicted poorer persistence following regulatory exertion (in this case, affect regulation) than in the control condition.

More precisely, we predicted that compared with their performance before watching the movie, the performance of participants who regulated their emotions should decline more than the performance of participants who did not regulate their emotions. This decline in performance should also be related to how tired participants felt after regulating their emotions and how much effort participants exerted in regulating their emotional response.

Manipulation of Regulatory Exertion

In Study 1 the manipulation of regulatory exertion was emotional regulation. Regulating an emotion requires overcoming one's current emotional state and replacing it with a different one. Past work has suggested that mood control is an effortful process. For example, in a study by Wegner, Erber, and Zanakos (1993), participants in either a sad or happy mood were told to make their mood either more positive or more negative. Half the participants were given a cognitive load, and the other half were not. Participants who tried to control their moods while under a cognitive load were much less successful in regulating their moods than participants who did not have the cognitive load, regardless of the direction of the regulation (either make the mood more positive or negative). Cognitive loads thus interfere with the effortful process of self-control (Wegner, 1994), which implies that emotional regulation is effortful and requires exertion to succeed.

One implication of Wegner et al.'s (1993) study was that mood regulation is effortful regardless of the direction of mood control. The cognitive load interfered equally with attempts to get into a sad mood or into a happy one. In a similar vein, Hochschild (1983) concluded that attempts to appear positive and friendly (for airline flight attendants) or to appear negative and threatening (for bill collectors) both require considerable amounts of acting and effort. DePaulo, Blank, Swaim, and Hairfield (1992) found that efforts to appear emotionally expressive and efforts to appear emotionally inhibited showed similar effects, including less success under close scrutiny (which may make the task more difficult), again suggesting that altering one's emotional state involves a similar exertion regardless of whether one is trying to alter it upward or downward.

Hence, in this study participants were instructed either to decrease or to increase their emotional response while watching an upsetting movie. In contrast, control subjects were not instructed to try to change their emotional responses at all. It is presumably difficult to alter one's emotional state in either direction, that is, either to amplify it or to diminish it, and so we anticipated that either increasing or decreasing an emotional response should require a comparable exertion of self-regulation. If the strength model is correct, then these exertions should impair subsequent self-regulation. In other words, the capacity for self-regulation should be depleted among participants who sought to increase their emotional response as well as among those who sought to diminish it, as compared with control participants who merely watched the movie without trying to alter their responses.

Dependent Measures

In this as in subsequent studies, we tried to include a measure of self-regulation that was conceptually and subjectively distinct from the self-regulation involved in the manipulation. This was done for two reasons. First, it would help eliminate possible alternative explanations based on familiarity, boredom, or other

responses to doing essentially the same task in both parts of the experiment. Second, if we could indeed find effects that carried over from one sphere of self-regulation to a very different sphere, this would indicate that the same common resource is used for widely different acts of self-control.

In Study 1, the initial manipulation involved affect regulation, and so the subsequent measure of self-regulation involved something quite different: task performance based on physical exertion and stamina. Many forms of self-control in everyday life require people to overcome physical discomfort. For example, one of the primary causes of resuming cigarette smoking after abstaining is physical discomfort, in particular, physical urges to smoke (Spring, Wurtman, Gleason, Wurtman, & Kessler, 1990; Zinser, Baker, Sherman, & Cannon, 1992). More generally, successful exertion among athletes, manual laborers, soldiers, and many others may require self-regulation to make oneself continue working despite physical fatigue.

To study physical stamina, we measured how long participants could continuously squeeze a handgrip. Squeezing a handgrip requires a great deal of effort; if one stops exerting for even a moment, one's grip will loosen. Prior research has concluded that maintaining a grip is almost entirely a measure of self-control and has very little to do with overall bodily strength (Rethlingshafer, 1942; Thornton, 1939). Time spent maintaining a grip did not load at all on a strength factor in these studies (Rethlingshafer, 1942; Thornton, 1939), nor did it correlate with maximum grip strength in other studies (Hejak, 1989). Thus, squeezing a handgrip is a well-established measure of self-regulatory ability.

Because performance on the handgrip was expected to vary as a function of hand strength, we measured performance both before and after the affect regulation manipulation. This allowed us to control for within-subjects variations in strength. We also included a second task, namely holding one's breath, but this proved too variable and unreliable to furnish meaningful data.

Method

Participants

Sixty (37 men and 23 women) Case Western Reserve University undergraduates recruited from introductory psychology courses participated in return for partial fulfillment of a course requirement. Participants were individually tested in one 30-minute session. The experimenter told participants that the purpose of the study was to examine how moods affect people's physical performance.

Initial Assessment of Regulatory Ability

After being briefed on the study and signing a consent form, participants' ability to self-regulate was assessed. Consistent with the cover story, the experimenter led participants to believe that the dependent measures of self-regulation were actually tests of strength and endurance, and this made it plausible that the experiment would measure performance right away. In reality, the purpose of this initial measure was to furnish an individual baseline for each subject that could be used for evaluating his or her performance after the affect regulation task.

Two preliminary measures were used. The first involved how long the subject could hold his or her breath, which was timed with a stopwatch. This was presented as an endurance test. It became apparent that the measure was imprecise, because some subjects would surreptitiously or perhaps unwittingly inhale small additional amounts of air while continuing to hold their breath, but in order to keep the procedure similar for all subjects the breath-holding exercise was retained.

The main premeasure involved squeezing a handgrip exerciser, which is a commercially available device for building up hand muscles. It consists of two handles connected by a metal spring. Squeezing the handles together compresses the spring. In order to furnish a precise measure of when the person stopped, the experimenter inserted a wad of paper between the two handles when the subject squeezed them together, and the handles held it in place. When the subject began to relax his or her grip, the paper would fall out. The experimenter started a stopwatch to time the performance when he placed the paper between the handles. When the piece of paper fell, indicating that the participant had released his or her grip, the experimenter stopped timing. To prevent participants from working toward a specific goal, the experimenter did not give the subjects any feedback (during or after the task) about their performance, nor were they allowed to look at a stopwatch or wristwatch during the performance.

Regulatory Exertion Instructions

After the initial assessment of regulatory capacity, participants received the manipulation of regulatory exertion. The experimenter told participants that they were going to watch a movie. One group of participants, the no emotional control condition, received no emotional regulation instructions and just watched the movie. Another group, the increase emotional response condition, was told to "really get into the movie," to feel as much emotion as possible and increase their emotional response. The final group, the decrease emotional response condition, was instructed to avoid letting the movie affect them and to hold back and decrease their emotional response. Additionally, the experimenter told participants in the experimental groups that they were being videotaped for a study on the facial expression of emotion and therefore should try to regulate their facial expression as well. Whereas participants in the increase emotional response condition were told to express as much emotion as they could on their faces, participants in the decrease emotional response condition received the exact opposite instructions and were told to express as little emotion as they could on their faces. Participants in the no emotional control condition received no instructions about their facial expression (but they were told they were being videotaped). Following these instructions, all participants saw a 3-min excerpt of the documentary *Mondo Cane* (Jacopetti, 1961), which discusses environment disasters (involving radioactive waste) and their calamitous effects on wildlife. The pathetic scenes of sick and dying animals were upsetting, which was indeed the intent of the filmmakers.

Thus all the participants saw the same movie and presumably had the same unpleasant emotional response to it. The three conditions differed only as to how they were instructed to deal with their emotional responses. At the end of the film participants completed the Brief Mood Introspection Scale (Mayer & Gaschke, 1988) to measure their mood and arousal levels.

After the participants finished the questionnaire, the experimenter assessed their regulatory performance again. The key measure was the duration of squeezing the handgrip. Participants then completed a manipulation check by rating their fatigue at the start of the study, after watching the movie, and at the end of the study on a 7-point scale (*not tired* to *extremely tired*). They also reported how much effort they exerted in complying with the manipulation of regulatory exertion instructions on a 7-point scale. The experimenter then debriefed, thanked, and dismissed the participants.

Results

Manipulation Check

Difficulty of the instructions. A one-way analysis of variance (ANOVA) found that on a 7-point scale the groups differed

in how effortful they found the self-regulation instructions (i.e., how much effort did it take to watch the movie, decrease your emotional response as you watched the movie, or increase your emotional response as you watched the movie), $F(2, 56) = 7.58$, $p < .001$. In particular, participants in the decrease emotional response condition reported that they found the manipulation of regulatory exertions much more effortful ($M = 3.3$) than participants in the no emotional control condition ($M = 1.9$), $t(38) = 3.47$, $p < .01$. Likewise, participants in the increase emotional response condition indicated that the manipulation of regulatory exertion instructions was much more effortful ($M = 3.0$) than participants in the no emotional control condition, $t(37) = 3.59$, $p < .001$.[2]

Moreover, participants in the decrease and increase emotional response conditions did not differ in how effortful they found the regulatory instructions, $t(37) = .71$, *ns*. Thus, participants who regulated their emotions exerted more effort than participants who did not regulate their emotions. This finding was also supported by a focused contrast, $F(1, 57) = 14.46$, $p < .0005$.

Mood state at the end of the film clip. A one-way ANOVA on the two mood subscales indicated that the three conditions did not differ in either valence of mood (pleasant versus unpleasant) or arousal at the end of the film clip, $F(2, 57) = .062$, *ns*; $F(2, 57) = 2.12$, *ns*, respectively. Thus any difference in self-regulation performance between the groups was not due to differences in emotional state or arousal.

Change in fatigue level after manipulation of regulatory exertion. Finally, on the self-report of fatigue, participants felt more tired after watching the movie than before (mean change on a 7-point scale was .383), $t(59) = 2.85$, $p < .01$. A focused contrast suggested that participants in the increase emotional response condition and decrease emotional response condition reported more increase in fatigue from before to after the movie, as compared with no emotional control condition participants, $F(1, 57) = 3.84$, $p = .05$. This difference suggests that people found it more tiring to try to alter their emotional states in response to the movie, as opposed to merely watching the movie.

Physical Performance

Change scores were computed by subtracting each participant's initial handgrip duration time from his or her final time. A one-way ANOVA performed on these changes in time indicated significant variation among the three conditions, $F(2, 57) = 3.34$, $p < .05$. See Table 1 for the means and standard deviations for time squeezing the handgrip.

Planned comparisons of the mean change in performance between each condition found that participants in both of the emotion regulation conditions squeezed the handgrip for far less time the second time than the first time compared with participants in the no emotional control condition. The performance of participants who tried to suppress emotional responses declined more (mean difference in time holding the handgrip from Time 1 to Time 2 was −18.5 s) than the performance of participants in the no emotional control condition ($M = -1.57$ s), $t(38) = 1.98$, $p < .05$. Likewise, the endurance of subjects who had tried to increase their emotional responses also declined more ($M = -25.10$ s) than control subjects, $t(38) = 2.32$, $p < .025$. There was no difference between the two affect regulation conditions, $t < 1$, *ns*. A focused contrast found that the two affect regulation conditions differed significantly from the no emotional control condition, $F(1, 58) = 6.18$, $p < .025$.

Table 1
Regulatory Performance in Study 1

Condition	Time 1	Time 2	Change
Increase emotional response	78.73	53.63	−25.10
No emotional control	60.09	58.52	−1.57
Decrease emotional response	70.74	52.25	−18.49

Note. Numbers under Time 1 and Time 2 represent mean times that participants squeezed the handgrip, in seconds. Standard deviations for Time 1, top to bottom, are 49.93, 35.14, and 47.70. For Time 2, they are 31.62, 32.36, and 31.76. Rightmost column represents change in performance, in seconds, from Time 1 to Time 2. $n = 20$ in each condition.

One question about the differences between cells is whether the relatively poorer performance of affect regulation subjects actually reflected an improvement by control subjects, due to a practice or other effect. To test this, we compared each of the change scores against zero. Both affect regulation conditions showed significant declines in handgrip endurance from the pretest to the posttest, $t(19) = 3.26$, $p < .01$ for the subjects who enhanced their emotional responses, and $t(19) = 3.39$, $p < .01$ for those who suppressed. In contrast, the mean change score in the control condition did not differ from zero, $t(19) < 1$, *ns*. Thus, it appears that either trying to amplify or stifle one's emotional response led to an absolute reduction in physical endurance as measured by the handgrip, whereas control subjects showed no change from the pretest to the posttest. The decline in performance following self-regulation is thus not merely relative.

The decline in time holding the handgrip also correlated with participants' rating of how much effort they exerted in controlling their emotions. The correlation between the change in the time squeezing the handgrip and self-rated effort exerted in controlling their emotions was $r(59) = -.27$, $p < .05$. Similarly, the correlation between the participants' tiredness at the end of the movie and the decline in the ability to squeeze the handgrip was $r(60) = -.23$, $p = .07$. Thus the effort that participants exerted while regulating their emotional response as well as how tired they felt after regulating their emotional response predicted their dropoff in self-control performance.

Discussion

Study 1 provided initial support for the view that self-regulation operates like a strength or reserve of energy in that we found evidence of regulatory depletion when people had to perform two consecutive acts of self-regulation. Trying to alter one's emotional state led to a subsequent drop in physical stamina, as measured by how long people squeezed a handgrip.

[2] One participant in the increase emotional response condition did not answer the question about how effortful he found the regulatory instructions; his data are dropped from any analysis involving this question. Otherwise this participant did not differ from the other participants.

These results suggested that self-regulation in one area reduced the subsequent ability to self-regulate in another area.

The results cannot be attributed to negative affect per se. Control subjects watched the same upsetting stimulus movie and reported the same emotional response, but their physical stamina was unchanged from the premeasure to the postmeasure. Thus it appears that trying to alter one's emotional state, rather than the emotional state per se, was responsible for regulatory depletion.

The results also suggest that the effects are not limited to inhibitory efforts. People who tried to amplify and vividly express a strong emotional reaction showed subsequent decrements quite similar to the response of people who tried to suppress their emotions. The direction of affect regulation is apparently irrelevant: Strength or energy is depleted by regulatory efforts in either direction.

Participants also felt more fatigued after watching the movie than before watching it. This indicates that regulatory exertion may lead to conscious sensations of fatigue and increased feelings of tiredness, which the limited resource model predicts. If self-regulation is effortful and requires exertion, it follows that self-regulation may lead to conscious sensations of fatigue.

Study 2

Study 2 was intended as a conceptual replication of Study 1 using very different methods. Instead of asking people to alter their emotional states, we asked them to suppress a forbidden thought. Instead of measuring muscular endurance on a handgrip, we measured their persistence at unsolvable anagrams. We predicted that people who had striven to suppress certain thoughts would give up faster on the anagram task. This finding would converge with the results of Study 1.

Manipulation of Regulatory Exertion

Study 2 used thought suppression as its manipulation of regulatory exertion. We borrowed the procedure developed by Wegner et al. (1987) in which the participant is instructed not to think about a white bear. The underlying assumption was that attempting to suppress a thought should require much more effort than either deliberately expressing the thought or letting one's thoughts run naturally. Trying to express a thought should not require as much effort.

Research by Wegner and his colleagues (Wegner, 1992; Wegner et al., 1987) has supported the idea that suppressing thoughts is effortful, whereas deliberately expressing them is not. For example, Wegner et al. (1987) gave participants instructions to say out loud their thoughts as they either thought about a white bear (express condition), or tried not to think about a white bear (suppress condition). Participants had a hard time not thinking about the white bear; their thoughts often returned to what they were trying to suppress. In contrast, participants in the express condition were quite successful at thinking about the white bear more. This suggests that thought suppression is difficult and effortful, whereas thought expression is much easier. On that basis, we predicted that the thought suppression condition would deplete the person's regulatory capacity, whereas little or no depletion should occur in the expression condition. Subsequent self-regulation should therefore be impaired mainly in the suppression condition.

In this respect, the thought control manipulation was not entirely parallel to our affect regulation manipulation in Study 1. We considered self-regulation to be involved both when the person was trying to stifle or to amplify the emotional response. In Study 2, however, only suppressing thoughts is considered to require self-regulation, whereas expressing thoughts that were permitted (although not required) to include white bears was not considered as an act of self-regulation. This approach does seem most consistent with what previous work has found. The deciding factor may well be that thought control researchers have permitted but not required participants in the expression condition to think about white bears. If the instructions were that the participant should try to think continuously and exclusively about white bears, then this too would constitute an act of self-regulation. But in a sense it is simply another form of thought suppression, insofar as concentrating on white bears involves shutting out all other thoughts.

Persistence as Dependent Measure

As in Study 1, we sought a measure of self-regulation that would have no apparent relation to the initial manipulation. For Study 2 we chose to have people perform an anagram-solving task. Unbeknownst to them, the anagrams were unsolvable, so we could measure persistence in the face of failure. It presumably requires considerable exertion of self-control to make oneself keep trying at a task when one is fatigued and discouraged by a series of failures. Persistence at unsolvable puzzles has frequently been used as a behavioral measure of frustration tolerance (e.g., Glass, Singer, & Friedman, 1969). For our purposes, what mattered was that persistence required the person to override an easy, appealing response (i.e., quitting) and hence constituted self-regulation. Participants with less regulatory capacity—presumably, the ones who had depleted their capacity by the previous thought suppression exercise—should therefore quit the task sooner than other participants.

Method

Participants

Fifty-eight (30 men and 28 women) Case Western Reserve University introductory psychology students participated in the study in return for partial fulfillment of a course requirement. Seven participants were not native speakers of English and were therefore dropped from the study; thus the data for 51 participants (28 men and 23 women) were analyzed. Participants were run in individual sessions of approximately 30 min. The experimenter told participants that the purpose of the study was to "see how people use words; how people read," and consisted of two distinct parts: (a) using words in sentences and (b) using letters to form words.

Manipulation of Regulatory Exertion

After signing a consent form, participants were told that the first part of the study examined how people use words in sentences. The experimenter told them that unlike most experiments that constrain people to writing a paragraph on a specific topic and then analyzing how they use words in sentence form, in this study they would generate their

own sentences. Participants were told to write down all their thoughts on a piece of paper, one thought per line, so that the experimenter could see "how you use words in naturally occurring sentences."

At this point, the experimental manipulation was given. Following the procedures outlined in Wegner et al. (1987), participants were randomly assigned to one of three regulatory exertion conditions: (a) they were either told to think about a white bear as much as they could (express thoughts condition), or (b) told to try not to think about a white bear (suppress thoughts condition), or (c) were given no special thought control instructions (no thought control condition). Participants were told that these instructions were to "help direct their thoughts" as they generated the sentences. Additionally, participants in both the express and suppress thoughts conditions put a check mark in the margin of the paper every time they thought of a white bear, to further focus their attention on the experimental manipulation. The experimenter then left the room and the participants wrote down their thoughts for 6 min.

Dependent Measure

At the end of the 6 min, the experimenter reentered the room and told the participants to stop writing. To help maintain the cover story, the experimenter told the participants that they would now do the second part of the study investigating how individual letters remind people of words. Participants then received a list of anagrams to solve, with an explanation of how to solve them and the instructions, "This is not a test. Work on them for as long as you want, and when you want to stop, just ring the bell on the table." Approximately 2 min separated the end of the thought control manipulation and the beginning of the anagrams, while the experimenter gave these instructions. The experimenter then left the room and began surreptitiously timing how long the participants worked on the anagrams. When participants rang a bell to stop working on the anagrams, the experimenter noted the time and reentered the room. The experimenter stopped participants who were still working after 20 min and recorded their time as 20 min. Participants then completed a manipulation check by rating on a 7-point scale how difficult they found the manipulation of regulatory exertion instructions (the thought control instructions). Following this, the experimenter probed the participants for suspicion regarding the experimental manipulations, and then thanked and debriefed them. No participant indicated awareness of the true intent of the study nor was anyone aware of being timed on the second part of the study, and no people believed that their performance on the first part of the study had any impact on their performance on the second part of the study.

Results

Manipulation Check

A one-way ANOVA indicated that participants in the three conditions differed in how hard they found the manipulation of regulatory exertion on a 7-point scale, $F(2, 48) = 6.24$, $p < .005$. In particular, participants in the suppress thoughts condition rated the manipulation of regulatory exertion task harder ($M = 3.88$) than participants in the no thought control condition ($M = 2.18$), $t(32) = 3.36$, $p < .0025$. Similarly, participants in the suppress thoughts condition rated the manipulation of regulatory exertion harder than subjects in the express thoughts condition ($M = 2.65$), $t(32) = 2.37$, $p < .025$. Participants in the express thoughts and no thought control conditions did not differ in how hard they found the manipulation of regulatory exertion, $t(32) = .939$, $p > .35$. A focused contrast further supported the idea that the suppression condition was different from the other two conditions, $F(1, 49) = 6.81$, $p < .025$.

Table 2
Mean Persistence on Unsolvable Anagrams, Study 2

Condition	*M*	*SD*
Suppress thoughts	563	240
No thought control	758	280
Express thoughts	867	280

Note. Numbers under *M* represent mean duration in seconds of persistence. $n = 17$ in each condition.

This pattern replicates evidence from prior research and confirms an important assumption of the present study, namely that suppressing thoughts requires a more difficult and strenuous act of self-control than either expressing thoughts or letting one's thoughts go with no instructions. It does therefore appear justified to predict that the suppress thoughts condition would differ from the other two in terms of involving a preliminary act of self-regulation.

Persistence Versus Quitting

A one-way ANOVA indicated that the three groups differed in how long they spent working on the anagrams before they rang the bell, $F(2, 48) = 5.64$, $p < .01$. Planned comparisons among the group means found that participants in the suppress thoughts condition ($M = 563$ s) quit sooner than participants in the no thought control condition ($M = 758$ s), $t(32) = 2.18$, $p < .05$. Participants in the suppress thoughts condition also quit sooner than participants in the express thoughts condition ($M = 867$ s), $t(32) = 3.40$, $p < .0025$. There was no difference between the two control conditions (i.e., no thought control, and express thoughts), $t(32) = 1.14$, *ns*. Thus, participants in the suppress thoughts condition quit sooner than participants in the other two conditions, and this conclusion was confirmed by a focused contrast, $F(1, 49) = 9.86$, $p < .005$.[3] The means are presented in Table 2.

Discussion

The results of this study provided further support for the view that self-regulation involves a limited capacity that can become temporarily depleted. Participants who had suppressed their thoughts subsequently quit working much sooner on a frustrating, open-ended task, as compared with participants who had either expressed their thoughts or had just written down their thoughts with no special thought control instructions. Apparently, the initial effort to suppress forbidden thoughts about a white bear depleted some capacity, leaving those individuals less able than others to resist the impulse to give up in the face of discouraging failure at unsolvable anagrams. Wegner's model of ironic processes (1994) suggests that consciously trying to

[3] Dropping participants who never stopped (i.e., worked the full 20 min) had no effect on the main effect for condition nor the planned comparisons of the group means. Both remained highly significant, for example, main effect for condition, $F(2, 41) = 4.79$, $p < .025$. Their data are reported here for completeness.

avoid a response is very difficult and requires a great deal of resources. Although Wegner (1994) was primarily focused on attention as a resource, it is possible that regulatory capacity may also be a resource that influences the ironic process. Indeed, people who are lower in regulatory resources may have greater difficulty than others in suppressing thoughts and hence may be more prone to ironic effects.

An alternative explanation for the results of Study 2 is possible. One could argue that thought rebound effects (instead of depleted regulatory capacity) may have contributed to causing people to quit the frustrating task sooner. Thought rebound is the tendency for thought suppression to be followed by a heightened frequency of intrusions of the previously forbidden thought (Wegner et al., 1987). To be sure, this alternative explanation would not explain the results of Study 1 and therefore lacks parsimony. It is also unclear just how or why thought rebound effects would influence the decision to quit working on anagrams. Still, one could hypothesize that rebounding thoughts about white bears interfered with the anagram task and therefore made it seem more difficult in some way.

For this reason, we conducted Study 3 using the same thought suppression exercise but following it with a task for which any intrusion of distracting thoughts would help rather than hurt. Specifically, the dependent measure of self-regulation in Study 3 involved controlling one's emotional response to an amusing stimulus video. If thought suppression causes rebounding thoughts that distract people during subsequent tasks, then this should make it easier to avoid smiling and laughing in response to a funny video, because the distraction should help minimize the subjective impact of the video.

Study 3

Study 3 sought to provide another replication of the regulatory depletion effect and to rule out several alternative explanations. In Study 3, we used the same thought suppression manipulation as in Study 2, and afterward we measured how well people could control their amusement in response to a humorous stimulus video.

As already noted, one purpose of Study 3 was to rule out the alternative explanation that the effects of Study 2 were mediated by a rebound of the suppressed thought that distracted people during the subsequent task and made it harder. Such a distraction would presumably make it easier rather than harder to succeed at Study 3's follow-up task. Another goal of Study 3 was to compare the effects of self-regulation with another task that would also require exertion (but not self-regulatory exertion). Pretesting suggested that solving moderately difficult mathematics problems is perceived as similar in difficulty to suppressing thoughts about a white bear, and so we used math problems as the control condition. Solving math problems should not require a great deal of self-regulation, especially compared with regulating thoughts. Participants in this study were able to solve the problems, so there was no need for self-regulatory exertions to persist in the face of failure (as in Experiment 1). Indeed, math problems generally (and in this study specifically) involve applying standard procedures to go from the problem to the solution, and the whole issue of overriding responses (which is what self-regulation is mainly about) is irrelevant.

Another possibility is that the initial act of self-regulation could conceivably produce differential moods that might mediate effects on the subsequent task. This would not necessarily be an alternative explanation to regulatory depletion but it would change the implications about how the effect occurs. Study 1 does render a differential mood explanation doubtful, because both amplifying and suppressing the sad reaction produced the same effect on subsequent physical performance. Still, Study 3 included a mood measure right after the initial manipulation.

Additionally, Studies 1 and 2 both used persistence (albeit in quite different forms) as the dependent measure of self-regulation. To increase generality, we used a dependent measure in Study 3 that involved success at controlling one's emotional response, instead of another persistence measure. This measure was also useful to address any concern that the effect of initial self-regulation is simply a tendency toward passivity and reduction in overall behavior. In other words, we wanted the dependent measure of self-regulation in Study 3 to be constructed so that loss of self-control would lead to more behavior rather than less, unlike the previous two studies. In Study 3, successful self-regulation on the dependent variable was signified by an absence of overt (and covert) behavioral response: Success meant showing no amusement. Failure would be indicated by ample behavioral signs such as smiling, laughing, and generally showing amusement.

Method

Participants

Forty-nine (39 men and 10 women) undergraduates recruited from introductory psychology courses participated in return for partial fulfillment of a course requirement. Participants were individually tested in one 30-min session. The experimenter told participants that the purpose of the study was to look at what influences people's ability to hide their emotions. The importance of being able to hide one's emotions successfully was stressed.

Manipulation of Regulatory Exertion

After being briefed on the study and signing a consent form, participants were given the self-regulation manipulation task. Consistent with the cover story, the experimenter led participants to believe that the manipulations were actually personality tests. One group of participants, in the math problem condition, was given moderately difficult multiplication problems to solve (three digit by three digit multiplication). The other group of participants, the suppress thoughts condition, were told to write down their thoughts on a piece of paper while trying to avoid thinking about a white bear, just as in the suppress thoughts condition in Study 2. Pretesting indicated that both tasks were perceived as equal in difficulty and unpleasantness, but the suppress thoughts condition should involve more self-regulation. After working on the assigned manipulation task for 5 min, the experimenter stopped participants and gave them a manipulation check and the Brief Mood Introspection Scale (Mayer & Gaschke, 1988).

Participants then watched an 18-min humorous video tape, consisting of skits taken from a television program (*Saturday Night Live*; Above Average Productions, 1985) and a stand-up comedian (Robin Williams; in Mischer, 1982). The experimenter told participants to avoid showing any amusement while watching the video. They were told to avoid laughing, smiling, or otherwise responding in any way to the videotape. Participants' facial expressions were videotaped for subsequent coding.

Coding of Video Tapes

The ratings of each participants' facial expression are the main dependent measures of this experiment. The raters were not aware of the experimental conditions. The raters judged how much each participant smiled and how much each participant laughed, and provided a general rating of the participants' success in controlling their amusement.

Results

Mood Effects

Participants in the math problem condition did not differ from participants in the suppress thoughts condition in how aroused they were after the manipulation $t(47) = 1.15$, *ns*. The two conditions did not differ in the valence of their mood either, $t(47) = .63$, *ns*. Thus, participants were in the same mood, regardless of experimental condition. Mood effects or frustration cannot account for any of the results.

Interrater Reliability

The correlation between the two raters' agreement on the participants' ability to control their amusement was acceptable. The mean interrater reliability was .71. Thus, the raters agreed reasonably well on how well participants were able to control their emotional expressivity. Discrepancies between raters were resolved by using the first rater's codings.

Self-Regulation

The main focus was on how well people could control their emotional expression. Each participant's facial expressions (on videotape) were coded for smiling, laughing, and overall success at controlling his or her amusement. High scores on the measures reflect relative failure of self-regulation. See Table 3 for the means and standard deviations for each measure.

Smiling. The overall rating of how much participants smiled differed between conditions. Participants in the suppress thoughts condition were rated as smiling more overall ($M = 2.4$) compared with participants in the math problem condition ($M = 1.4$), $t(47) = 2.07$, $p < .05$, consistent with predictions. Participants in the suppress thoughts condition were much more likely to smile at the movie than participants in the math problem condition.

Laughing. The ratings on laughter yielded weaker effects than smiling, possibly because of a floor effect. Laughing aloud while watching a film alone seems to have been fairly rare. The overall laughter ratings were in the predicted direction, with subjects in the prior suppress thoughts condition laughing more ($M = 1.5$) than subjects in the prior math problem condition ($M = 0.7$), but the difference failed to reach significance, $t(47) = 1.44$, *ns*.

Overall amusement. Apart from the behavioral ratings of smiling and laughing, we obtained ratings of overall display of amusement during the videos. These presumably indicate overall success at controlling emotion. Participants in the suppress thoughts condition were rated as showing more amusement overall ($M = 2.5$) than participants in the math problem condition ($M = 1.3$), $t(47) = 1.95$, $p = .05$. Overall, participants in the suppress thoughts condition were rated as less able to control their emotional expression compared with participants in the math problem condition.

Table 3
Emotional Expressivity, Study 3

Condition	Smiling	Laughing	Overall amusement
Math problems	1.39	0.74	1.30
Suppress thoughts	2.42	1.54	2.50

Note. Numbers indicate mean number of smiles and laughs during the video and coders' average rating of participant's overall amusement level. Standard deviations for top row, left to right, are 1.37, 1.42, and 1.71; for bottom row, 2.00, 2.30, and 2.47. $n = 23$ in math problems and $n = 26$ in suppress thoughts.

Reactions to Initial Task

Pretest subjects rated the math problems and the thought suppression tasks as about equally difficult. Actual subjects exhibited a marginally significant trend by which the thought suppression task was rated as possibly more difficult than the math task, $t(47) = 1.90$, $p = .06$, in response to the question of "how much effort did you exert on the task?" These latter ratings came after the emotion suppression task and may be contaminated by feelings of exertion on that task or by efforts to explain failure at emotion suppression.

To explore the possibility that differential exertion on the first task mediated effects on emotion suppression, we correlated responses to the exertion item with the main measures. The correlation with overall smiling was weak, $r(49) = .097$, *ns*, as was the correlation with overall laughing, $r(49) = .080$, *ns*, and with general amusement, $r(49) = .124$, *ns*. Thus, it does not seem that differences in self-reported exertion on the first task, especially between the math and thought suppression subjects, played a significant role in mediating the effects on emotional suppression.

Participants in the thought control condition reported liking the thought suppression task slightly more than participants liked the math problem task (mean rating on a 25-point scale, 14.0 vs. 10.9), $t(47) = 2.6$, $p < .025$. Thus, participants in the math problem condition may have been more frustrated than participants in the suppress thoughts condition. Still, ratings of pleasantness of initial task did not correlate significantly with any of the main measures of emotional suppression. We found no correlation with total smiling $r(49) = .068$, *ns*, with total laughing, $r(49) = .128$, *ns*, or with general amusement, $r(49) = .137$, *ns*.

Discussion

Study 3 replicated the finding that self-regulatory performance drops off after a prior attempt at self-regulation. Participants who had to regulate their thoughts by not thinking about a white bear subsequently were less successful at controlling their emotional responses: Despite instructions not to show amusement, they smiled more, tended to laugh more, and were rated as showing more amusement overall when watching a

funny movie, as compared with participants who had just solved difficult math problems. In other words, the initial experience of trying to control one's thoughts left them less able to control their emotions afterward.

Additionally, Study 3 addressed several interpretive questions and alternative explanations. It was deemed plausible that differential moods might have mediated the effects of Study 2, but in Study 3 we found that people reported the same moods and emotions in both conditions. In particular, participants in the suppress thoughts condition were neither more aroused nor more unhappy than participants in the math problem condition, which rules out mood or other phenomena such as reactance as a possible explanation of the subsequent drop in regulatory performance.

A related question was whether participants in the self-regulation conditions of Experiments 1 and 2 found those tasks more frustrating or unpleasant than participants in the control conditions, which reactions might have made them less willing to persist on the subsequent task. In Study 3, however, participants rated the self-regulation (thought suppression) task as less unpleasant than the control (math problem) task, so if task pleasantness were a mediator of self-regulation we should have found the math problem participants to perform worse than participants in the suppress thoughts condition—whereas in fact the opposite result was found.

We selected math problems as a comparison for the thought suppression task because solving math problems is difficult without requiring self-regulation, which would avoid any suggestion that the results of Studies 1 and 2 reflected differential exertion in general on the preliminary task. Pretest participants described the math problems and the thought suppression task as equally difficult. Participants in the actual study showed a trend according to which the thought suppression task was rated as having elicited marginally more exertion on their part than the math problems task. Although the difference was not significant, the trend may be enough to make some readers wonder whether the self-regulation task did indeed produce fatigue by requiring more exertion than the math problems task, so that the differential exertion on the first task led to the failure to control emotions on the second task. The direction of results calls this result into question, however: If people were indeed significantly more tired after suppressing thoughts of white bears than after doing math problems, the fatigue might well have produced less laughter than was found among people who had solved math problems, insofar as tired people should be less likely to laugh and smile.

A final concern about the results of Studies 1 and 2 was whether the effects simply reflected a reduction in activity per se as opposed to a reduction in self-regulation. Study 3 contradicted the reduced activity hypothesis. The initial act of self-regulation (thought suppression) led in Study 3 to an increase in smiling and other displays of amusement. Thus, the depletion of regulatory capacity does not result in reduced activity overall, but rather it results specifically in poorer self-control.

Study 4

Our final study had a twofold purpose. First, it was intended to provide another conceptual replication of the regulatory depletion effect, using quite different methods and measures than the first three experiments. Second, Study 4 sought to establish greater external validity, in the hope that this would facilitate generalizing the depletion effect to familiar experiences in everyday life. Studying some forms of regulatory failure in the laboratory, such as losing control over one's emotions, is difficult because it is impractical (and possibly unethical) to push participants to the point where they can no longer control their behavior adequately. Likewise, trying to find a natural situation in which people lose self-control is difficult because such environments are rare and often unpredictable. Thus we wanted to see if the limited resource model could explain self-control breakdowns that people often experience but that are difficult to study in controlled situations.

To fulfill these goals, we had participants write autobiographical stories (e.g., Baumeister & Newman, 1994; Gergen & Gergen, 1988; Harvey, Orbuch, & Weber, 1992; Harvey, Weber, & Orbuch, 1990; Murray & Holmes, 1993; Murray & Holmes, 1994; Ross & Holmberg, 1990) about situations in which they could control their emotions (regulatory success stories) and about situations in which they could not control their emotions (regulatory failure stories). Autobiographical narratives have external validity and are useful for studying phenomena that are otherwise too difficult, too dangerous, or too unethical to study in a traditional laboratory setting (e.g., Baumeister, 1988; Heatherton & Nichols, 1994). By contrasting stories about situations in which participants could control their emotions with stories about situations in which participants could not control their emotions, differences between the two situations were highlighted. Thus, one can see what unique factors may precipitate, facilitate, or contribute to the loss of control.

Consistent with the limited resource model, we hypothesized that participants would recall feeling more tired and more often mention other regulatory demands in stories about situations in which they could not control their emotions than in stories about times when they could control their emotions. For this study, the focus was on events, situations, and demands that preceded the loss (or non-loss) of control.

Method

Participants

Eighty-six undergraduates recruited from introductory and upper level psychology courses participated in return for partial fulfillment of a course requirement. Testing was done in one large group session (a class) and several smaller group sessions (one to four participants). Participants were repeatedly assured of the anonymity of their responses.

Procedure and Instructions

Participants were instructed to write accounts of two separate events in their lives: a time when they could control their emotions and a time when they could not control their emotions. Participants wrote about both events in the same testing session; thus any differences between the narratives was not due to individual differences between participants. The order of writing these stories was counterbalanced across participants, so that half the participants wrote about not being able to control their emotions first, while the other half wrote about a time when they could control their emotions first.

Participants received verbal instructions on how to write the narrative.

They were told to write about the circumstances and events that led up to an emotional experience. Participants were asked to write as much as they could and to be as thorough as possible. The experimenter did not explicitly tell the participants that the purpose of this study was to determine why self-control fails. Instead, participants were simply told that the focus was on emotional events and how people experience emotions. Thus, at no point did the experimenter tell participants that the purpose of this study was to examine potential causes for the loss of self-control. The experimenter then gave the participants paper on which to write their stories, with the topic for each story (i.e., "write about the events that led up to a time when you could/could not control your emotions") written at the top of the page. When participants finished writing the first story, they put it into an unmarked envelope and then received another piece of paper with the other topic written at the top of the page. After they finished writing the second story and placed it in the same envelope, the experimenter gave them a consent form to sign releasing their stories for use in this study and then gave them a written debriefing that explained the purpose, goals, and methods of this study.

Coding Strategy

An independent judge who was not aware of the research hypotheses typed and coded the stories. This judge coded the stories on various dimensions determined a priori to be important to the controlling of emotions and the limited resource model. For each story, the judge rated the presence versus absence of the particular dimension on a dichotomous scale. See the Results section and Table 4 for a list of the coding dimensions. A second judge recoded the stories to compute reliabilities. We resolved any differences between the two judges by retaining the first judge's codings. The agreement between the two judges on the coding dimensions (kappa) ranged from .82 to .96, with a mean of .89, indicating a high level of reliability for the ratings.

Results

Because some participants did not follow directions and failed to write a micronarrative and others did not describe situations in which they had to control their emotions, the final sample consisted of 80 stories about not being able to control an emotion and 79 stories about being able to control an emotion. We analyzed these stories using chi-square; the number of stories that contained a particular dimension was compared to the number of stories that did not mention that particular coding dimension. The results for the coding dimensions are summarized in Table 4.

Table 4
Results of Content Coding, Study 4

Coding dimension	Regulatory failure	Regulatory success
Exerted effort at self-control	3.8	15.2
Felt tired	7.5	2.5
Was drunk	6.3	0.0
Felt calm	0.0	11.4
Felt stressed	10.0	1.3
Other emotions than main present	21.3	11.4
Other regulatory demands present	11.3	3.8

Note. There were 80 regulatory failure stories and 79 regulatory success stories. Numbers under each column represent percentage of stories having the feature indicated.

Differences Between Stories

Effort. The limited resource model predicts that self-regulation is effortful. In these autobiographical narratives, participants reported exerting effort at self-control while regulating their emotions more often in the regulatory success stories than in the regulatory failure stories, $\chi^2(1, N = 159) = 6.09, p < .025$. Apparently, effort is linked to successful self-regulation. Times when participants did not or could not exert themselves are linked to failure to control their emotions. Exerting oneself is important for the success of self-regulation.

Tiredness and fatigue. Also, based on the limited resource model, we predicted that tiredness should be associated with a breakdown in self-control. Sensations of tiredness or fatigue may indicate a lessened ability to exert oneself. Because self-regulation depends on exertion, self-regulation should be poorer when one is tired. The data tentatively supported this hypothesis; there was a trend for participants to mention feeling tired more often in the regulatory failure than in the regulatory success stories, $\chi^2(1, N = 159) = 2.05, p < .15$.

We also looked for other factors that may alter regulatory capacity. One is alcohol, given that research in many spheres has shown that alcohol is associated with a broad range of self-regulatory failures (e.g., Baumeister et al., 1994). Participants mentioned being drunk much more often in the regulatory failure than in the regulatory success accounts, $\chi^2(1, N = 159) = 5.10, p < .025$. Being drunk is similar to being tired or having a reduced level of regulatory capacity because of alcohol's effect on arousal. Because alcohol lowers arousal and arousal is linked with exertion, it is possible that alcohol may interfere with one's ability to exert oneself. This may result in poorer regulation of behavior and emotions.

Meanwhile, being calm should be beneficial for self-regulation, insofar as one's regulatory capacity is not being depleted by the demands of coping with stress or emotion. Regulatory success stories were significantly more likely to indicate a feeling of being calm than were regulatory failure stories, $\chi^2(1, N = 159) = 9.66, p < .0025$. Being calm may indicate a high level of energy and potential for action (Thayer, 1989), and feeling calm is associated with a physical sensation of being rested and refreshed and not feeling fatigued, drowsy, or sleepy (Mayer, Salovey, Gomberg-Kaufman, & Blainey, 1991). Calmness may indicate increased regulatory capacity, less fatigue, and hence better self-regulation.

Other regulatory demands. The last set of codings concerned whether prior self-regulatory demands were mentioned. We approached this in several ways. The first was to examine all other regulatory demands together. These included reports of being under stress, references to coping with other emotions than just the main emotion being regulated, and references to other regulatory demands (which mainly involved the demands of interacting with others and especially trying to make a good impression). These were much more common in the regulatory failure accounts than in the regulatory success accounts, $\chi^2(1, N = 159) = 8.01, p < .005$. Thus, an omnibus coding supported

the main hypothesis that the capacity for self-regulation is depleted by multiple demands.

Next we sought to break the omnibus demands measure down by coding the various specific demands separately. The most direct measure was a coding of whether people spontaneously and directly mentioned that they had had to respond to additional self-regulatory demands shortly before the incident they were describing. Although this measure is the most precise, it is relatively insensitive because of the somewhat low rate of such references. There was a tendency for subjects to mention these prior regulatory exertions more often in their accounts of regulatory failure than in their accounts of regulatory success, but it narrowly missed achieving significance, $\chi^2(1, N = 159) = 3.16, p = .07$. These demands were other regulatory needs, such as trying to remain motivated while working, having to deal with people in some problematic situation, or trying to make a good impression.

Another approach was to examine codings for whether the person mentioned feeling under stress. The term stress has many meanings, but in the general population it is often used to refer to the experience of being subject to excessive, assorted demands. We assume that coping with stress requires self-regulation, and so it should result in some depletion of regulatory capacity. Indeed, references to feeling stressed were more common in the regulatory failure accounts than in the regulatory success accounts, $\chi^2(1, N = 159) = 5.68, p < .025$.

A last approach dealt with feeling multiple emotions. If people have multiple emotional reactions at the same time, they may try to alter several of them, which would likewise deplete the regulatory capacity. Regulatory failure accounts tended to have more references to other emotions (beyond the one that was the focus of the story) than regulatory success accounts, although this was not significant, $\chi^2(1, N = 159) = 2.82, p = .09$.

Assumptions of Analysis

As Baumeister, Wotman, and Stillwell (1993) noted when using a similar research design, the procedure of having each participant write both kinds of story violates the chi-square statistic's assumption of independence of observations. In this study, if participants have a habit of mentioning particular events in their stories (e.g., a predisposition to talk about being drunk), that could alter the results—but it would decrease the effect size and therefore weaken the statistical power of the findings. Thus, the design of this study is more conservative than having participants write only one story apiece. On the other hand, it is possible that participants were trying to highlight contrasts between the stories by mentioning dimensions in one story and deliberately ignoring them in the other story. If there is such a contrast bias, there should be an interaction between the order in which participants wrote the stories and the observed effects.[4] To test this hypothesis, we carried out a hierarchical log-linear analysis on each of the dimensions. On all seven coding dimensions, the three-way interactions between story order, story type, and result (i.e., coding dimension, present or absent) were not significant, $ps > .50$, indicating that the order in which the stories were written did not affect how the stories were recalled. In short, a contrast effect cannot explain the pattern of the results.

Discussion

The results of Study 4 were consistent with the predictions of the limited resource model. In people's accounts of their own experiences with self-regulation, various prior self-regulatory demands and indicators of regulatory capacity were associated with poorer (or better, depending on the indicator) self-regulation of emotion. First, effort was linked to success in self-regulation. Participants were more likely to mention exerting themselves in stories in which they could control their emotions than in stories in which they could not. Second, participants tended to be unable to control their emotions when they felt tired, although this effect failed to reach significance. Being drunk may be the functional equivalent of being tired and was also linked to poorer ability to control one's emotions. Similarly, calmness may indicate less fatigue, and it was associated with success in self-regulation. Finally, other demands that may require self-regulation were reported more often when participants could not control their emotions than when they could control their emotions.

We mentioned in the Introduction that there are two forms of limited resource models. One is the strength model we have featured, and the other is a constant capacity model. It must be acknowledged that the results of Study 4 are consistent with either model. Both models predict that concurrent demands on self-regulatory strength should impair self-regulation, and Study 4 clearly showed that people mention such factors when describing self-regulatory failures (e.g., being drunk). The two models differ as to whether the resource is depleted for a period following regulatory exertion. Although some results of Study 4 point toward that conclusion, the limited direct measure of references to prior regulatory exertion yielded only a marginally significant difference, and the fatigue measure might conceivably be reconciled with the constant capacity model.

Hence the results of this study do not exclusively favor the strength model, although they do consistently support its predictions. They contradict a priming or activation model, and they seem most consistent with a strength model, but a constant capacity model could probably accommodate them.

One must note that narratives are subject to biases and distortions that may result in the rewriting of the stories to fit a person's motivational and self-presentational needs. In prior experiments, the primary focus has often been on these distortions and what they may indicate about the writer's motivation (in particular, see Murray & Holmes, 1993, 1994). These stories are susceptible to distortions as well so that there are two potential explanations for these results: Either participants' a priori beliefs about self-control or the actual events led to the differences found in the stories. However, because the results of these stories

[4] Participants who wrote the regulatory success story second should write very different stories than participants who wrote the regulatory success story first. Participants who wrote the regulatory success story second will be contrasting that story with the regulatory failure story they wrote earlier, whereas participants who wrote the regulatory success story first would have nothing with which to contrast it.

converge with the results of Studies 1 to 3 and the limited resource model itself, we feel comfortable in accepting the results as having external validity.[5] It appears that the limited resource model can help explain self-regulatory failure both inside and outside psychology laboratories.

General Discussion

We have supplied converging evidence from several very different research methods, and it generally points toward the following conclusion: After people exercise self-regulation, they are subsequently less capable of regulating themselves, at least for a short time. It appears that self-regulation uses some resource that becomes depleted. The findings of this investigation point toward a strength model as the best currently available approximation of the nature of self-regulatory capacity.

The main findings can be summarized as follows. In Study 1, participants who tried to regulate their emotions (either by amplifying them or by stifling them) performed worse on a subsequent task of physical endurance, namely squeezing a handgrip. Control participants in that same study, who experienced the same emotional stimulus but did not try to regulate their emotions, showed no change in their subsequent endurance. In Study 2, participants who suppressed thoughts about an arbitrary stimulus (a white bear) were more likely to give up quickly on a subsequent, frustrating task (unsolvable anagrams) than did people in the control conditions. In Study 3, participants who had tried to suppress forbidden thoughts were subsequently less able to control their facial expressions and overall amusement, as compared with people who had solved difficult math problems. Thus, three experiments found decrements in self-regulation following an initial self-regulatory exertion.

Finally, Study 4 involved assembling and coding a sample of accounts of prior successful and unsuccessful attempts to regulate emotions. Accounts of self-regulatory failure were more likely to refer to factors that suggested a depleted capacity, such as being tired or drunk, whereas accounts of successful self-regulation were more likely to refer to being calm and to exerting effort on the regulation. References to other regulatory demands, including being under stress and trying to make a good impression, were significantly more common in the accounts of regulatory failure.

These four studies provide converging evidence that the capacity for self-regulation is a limited resource subject to temporary depletion, akin to strength or energy. Alternative models and metaphors that would depict self-regulation as primarily a schema or a skill do not fit these results as well. Engaging in self-regulation appears to lead to poorer subsequent self-regulation of other, unrelated behaviors. We found this pattern in three experiments that used very different manipulations and measures of self-regulation. It was also found in people's autobiographical accounts of their own actual previous experiences of self-regulatory success and failure.

Effort, Fatigue, and Alternative Explanations

The present findings also lend support to other, secondary assumptions of the limited resource model. Overall, the results suggest that fatigue may be one possible reason why self-regulation of one response is associated with poorer self-regulation for other behaviors subsequently. First, the results from Study 4 support the view that greater effort brings greater success at self-regulation, which is consistent with the view that successful self-regulation depends on effortful exertion. If one does not or cannot exert oneself, self-control may break down. One common reason why one may not be able to exert oneself is fatigue. The results of Studies 2 and 4 suggested that a conscious sensation of fatigue is associated with poorer self-regulation. Finally, Study 1 supported the hypothesis that self-regulation itself may lead to fatigue and tiredness. Participants felt more tired after regulating their emotions than before. Self-regulation requires exertion, which leads to fatigue, which leads to poorer subsequent self-regulation. Thus, engaging in self-regulation may cause poorer self-regulation in the near future through the mediating factor of fatigue.

Meanwhile, our findings contradict the predictions based on activation and skill models, and some of them also suggest that a constant capacity model may be inadequate. Such models are undoubtedly useful for explaining some aspects and functions of the self, but they do not appear to provide a useful model or analogy for self-regulation.

Models of sustained attention cannot explain these findings either, as research has found that interruptions result in improved performance in vigilance tasks (Parasuraman, 1984). In the present studies, the decrement in self-regulation was found even after a brief interruption (approximately 2 min in both Studies 1 and 2), and it generalized to domains that were unrelated to attention control (e.g., persistence on an impossible task, Study 2). Thus, vigilance models are not general enough to explain the decrease in regulatory performance observed in these studies.

Although alternative explanations may be proposed for some of these findings, we believe that the consistency of these results across studies using a wide range of methods, measures, and paradigms lends strong support to the limited resource model. Whereas one could argue that both Studies 1 and 2 used persistence (albeit in quite different domains) as the dependent measure of self-regulatory ability, Studies 3 and 4 did not. Similarly, participants in Study 4 may have experienced experimental demands to write their stories in a particular manner, but the laboratory studies' cover stories were designed to minimize this experimental demand. Study 3 also ruled out mood, frustration, and differences in task difficulty as a cause of the subsequent decline in self-regulatory performance. In sum, the present findings are best explained by models that treat self-regulatory capacity as a strength variable (see also Baumeister, Bratslavsky, Muraven, & Tice, in press).

Limitations and Issues for Future Research

Our experiments were based on the pattern of manipulating one exertion of self-regulation and then measuring another (sub-

[5] The stories can be considered self-report data, similar to a questionnaire. Some research is directed toward understanding biases in self-report data or questionnaires, whereas other research is merely interested in using the questionnaires once they have been validated. In this experiment, we were interested in using the stories as an objective source of information, with the validation coming from the first three experiments.

sequent) one. It is conceivable that the patterns we observed are somehow limited to the specific manipulations or measures we used, although we tried to use very different manipulations and measures in the three studies. The purpose of this first investigation was necessarily to show the depletion pattern (i.e., self-regulation leads to subsequent impairment of self-regulation), but further work may find it useful to develop and test hypotheses about boundary conditions. A review of literature has also found that prior research is consistent with the depletion hypothesis and inconsistent with alternative hypotheses, such as learned helplessness (Seligman, 1975) or negative moods or arousal (see Muraven & Baumeister, 1997 for a review). Additionally, the strength model shares characteristics in common with other models of adaptation, in particular the "psychic cost" model of Glass and Singer (1972). Indeed, the present research borrowed some of the measure of regulatory capacity from their work. Their model was concerned with dealing with stress, however, and the strength model is concerned with self-regulation in general, of which coping with stress is only a small subset.

Also, if regulatory capacity is a strength, then repetitive exertions of self-regulation may lead to fatigue in the short run but may build up strength in the long run. Thus after self-regulation, regulatory ability should decrease for a short time and then increase to slightly above the previous, baseline level. The converse of this may also be true: Not exercising self-regulation may lead to less fatigue in the short-term but decreased ability to self-regulate in the long-term. The ability to exert oneself may fade away if it is not used. Indeed, we have some preliminary evidence to support these hypotheses (Muraven, Baumeister, & Tice, in press).

We approached our investigation with competing predictions from schema, skill, and strength models of self-regulation. Although our results fit the strength model and contradicted the other two, this does not mean that knowledge structures and acquired skills are irrelevant to self-regulation. The pervasiveness and complexity of self-regulation in human life may mean that there is room for all three models to be relevant in different ways. Our results suggest that the faculty that exerts direct control and alters the self's responses resembles a form of strength. Still, effective employment of that faculty and optimal use of it across different contexts may also benefit from learning, knowledge, and perhaps even skill. Self-management, for example, depends on individuals knowing what they can accomplish and what conditions permit them to perform optimally (Wagner & Sternberg, 1985). Future research may seek to elucidate the interplay of multiple kinds of self-regulation processes.

Implications and Concluding Remarks

The capacity of the self to alter its own responses is one of its most important functions, and indeed its centrality has led writers such as Higgins (1996) to speak of "the sovereignty of self-regulation" (p. 1062). The present investigation addressed the basic question of the nature of this capacity by examining how one act of self-regulation will affect a subsequent one. Our main findings fit the pattern of regulatory depletion: Self-regulatory exertions are often followed by temporary decreases in self-regulation in other, unrelated spheres. This pattern suggests that the capacity for self-regulation is a limited resource, akin to strength or energy. To use it is to lose it, at least temporarily.

Practical implications may be suggested. Success in many spheres of life depends on self-regulation, and people are often vexed at their failures to save money, lose weight, finish difficult tasks, keep promises and resolutions, manage their emotions, justify others' trust in them, break bad habits, resist temptations, and the like. The present results suggest that such individuals would be well advised not to attempt multiple changes at once. For example, each January people bemoan the presumably widespread failure to keep the resolutions made so fervently on the first day of the new year, but the very fact of making several resolutions on the same day may decrease their chances of success. By the same token, it may be reasonable to anticipate that when life circumstances place extra demands on one's self-regulatory resources (such as with the birth of a new baby, during final examinations, or when adjusting to new circumstances), self-regulation will begin to fail in other spheres (e.g., dieting, drinking, smoking, emotional control) where control has normally been successful. The judicious management of one's self-regulatory capacity may be most conducive to success, health, and happiness in the long run.

The self is undoubtedly a multifaceted entity, and different facets seem to operate on different models. Some aspects of self, such as self-conceptions, follow patterns of schematic activation (see Tice, 1992). Others, such as self-presentational patterns, resemble skills that are learned over time (e.g., Tice, 1991, 1993; Tice, Butler, Muraven, & Stillwell, 1995). The present results suggest that one important yet often neglected aspect of the self—the capacity of the human organism to alter and override its own responses—operates like a strength. That is, it is a central, limited resource that becomes temporarily depleted through exertion.

Two other implications of our results fit together in a disturbing fashion. In our studies, self-regulation in one sphere impaired subsequent self-regulation in quite different spheres, suggesting that efforts to control thoughts, feelings, physical endurance, and task persistence all draw on the same limited resource. This resource must therefore be regarded as a fairly important aspect of the self. Meanwhile, our findings also suggest that this resource is quite severely limited. The initial acts of self-regulation in Studies 1 to 3 were quite brief, but they had significant and indeed sizable effects. In Study 1, for example, trying to amplify one's emotional response to a video for a scant 3 min was enough to reduce subsequent physical stamina by about one third.

If the same resource is used for many (or conceivably all) acts of self-regulation, one might well wish that the resource would be large. Apparently it is not—at least according to the present data. If further work corroborates these conclusions, then the normal functioning of the self must face a recurrent dilemma of how to accomplish a lot with a little. In other words, the management of this powerful but scarce resource may be an important everyday challenge for the self.

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