SELF-EFFICACY, SELF-CONTROL AND EXERCISE PERFORMANCE

THE EFFECTS OF SELF-EFFICACY, SELF-CONTROL STRENGTH AND NORMATIVE FEEDBACK ON EXERCISE PERFORMANCE

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LAY ABSTRACT

Self-control failures are at the heart of many societal problems. A dominant theoretical view suggests self-control is governed by a limited internal resource. However, this perspective has recently been opposed by theorizing and evidence suggesting that people experience self-control failures due to shifts in motivational-cognitive processes. This thesis integrated three theories of self-control (i.e., strength model of self-control, control theory, and self-efficacy theory) in an attempt to provide a more complete understanding of why self-control failures occur for people performing demanding physical exercise. Findings suggest that each theoretical perspective provides complementary explanations for why self-control failures occur and how they can be overcome through shifts in cognitive processing. Specifically, self-control exertion leads to subjective fatigue, which decreases self-efficacy to exert self-control, and in turn reduces self-control performance. Furthermore, after self-control exertion, positive normative performance feedback increases self-efficacy and subsequent self-control performance whereas negative feedback drastically reduces self-efficacy and performance.

ABSTRACT

The strength model of self-control suggests that self-regulation and self-control processes are governed by finite internal energy resources. However, this perspective has recently come under scrutiny suggesting that self-control processes are not solely constrained to limited resources and may also be guided by motivational-cognitive processing. Self-efficacy theory and control theory are two theoretical views of self-regulation that also suggest self-regulation failures are dependent on motivational-cognitive processes; however the potential role of limited resources has not been evaluated in the context of these theoretical views. This dissertation sought to advance our understanding of self-regulation and self-control of exercise behaviour by integrating the three theoretical perspectives discussed above.

Study 1 showed that self-control depletion leads to reductions in task self-efficacy mediating the self-control depletion – negative performance change relationship. Overall, findings are consistent with self-efficacy theory. However the results are limited as the mechanism(s) leading to reduced self-efficacy following self-control depletion remain unclear.

Study 2 explored a sequential (serial) mediation model investigating the idea that exerting self-control leads to an altered psychophysiological state increasing subjective fatigue, which in turn, leads to reduced self-efficacy to exert self-control and reductions in physical self-control performance. Findings supported the proposed sequential mediation model. However, it remains unclear to what extent that self-efficacy plays a passive or active role guiding self-controlled behaviour following self-control depletion.

Study 3 explored the independent and interactive effects of self-control depletion and normative performance feedback on self-efficacy and physical self-control. Findings showed an interaction between self-control depletion and feedback. Findings support predictions of control theory when self-control resources are intact, but suggest feedback information is processed differently when self-control strength is depleted. Overall, results show that when self-efficacy is manipulated by feedback the effects of self-control depletion on performance are no longer evident supporting self-efficacy's role as an active causal mechanism determining behaviour.

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

CHAPTER 1: INTRODUCTION

CHAPTER 3: Self-control strength depletion reduces state self-control capacity, task self-efficacy, and impairs resistance exercise performance

CHAPTER 4: Effects of performance feedback on self-efficacy and exercise performance are moderated by self-control strength depletion

TABLES

CHAPTER 2: Self-control strength depletion reduces self-efficacy and impairs endurance exercise performance

CHAPTER 3: Self-control strength depletion reduces state self-control capacity, task self-efficacy, and impairs resistance exercise performance

CHAPTER 4: Effects of performance feedback on self-efficacy and exercise performance are moderated by self-control strength depletion

LIST OF ABBREVIATIONS

AD-ACL	activation-deactivation adjective check list-short form
ANOVA	analysis of variance
BMIS	brief mood introspection scale
COEFF	regression coefficients
DOI	digital object identifier
FA	feedback awareness
fMRI	functional magnetic resonance imaging
ID	identification
IMI	intrinsic motivation inventory
k^2	kappa-squared
M	mean
M_1	mediator one
M_2	mediator two
MVC	maximum voluntary contraction
MVPA	moderate-vigorous physical activity
NGSE	new general self-efficacy scale
NRS	normative rating scale
1RM	one repetition maximum
lbs	pounds
REP	repetition
RISE	relation-inferred self-efficacy
RPE	ratings of perceived physical exertion
RPM	revolutions per minute
RPME	ratings of perceived mental exertion
SCS	self-control scale
SD	standard deviation
SE	standard error
SPSS	statistical package for the social sciences
SSCCS	state self-control capacity scale
TM	trademark

PREFACE
DECLARATION OF ACADEMIC ACHIEVEMENT

This thesis is prepared in the “sandwich” format as outlined in the School of Graduate Studies’ Guide for the Preparation of Theses. It includes a general introduction, three independent studies prepared in journal article format, and a general discussion. The candidate is the first author on all of the manuscripts. At the time of the thesis preparation, Chapter 2 was in press and Chapter 4 was under peer-review.

CONTRIBUTION TO PAPERS WITH MULTIPLE AUTHORSHIP

Chapter 2 (Study 1)

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J. D. Graham's role in Study 1:

- Conceived the research question and study design
- Author of ethics application at McMaster University
- Contributed to study design and measure selection
- Lead investigator responsible for data collection, analysis and interpretation
- Primary author of manuscript

Role of co-author in Study 1:

- SB provided feedback about the study design and obtained funding
- SB assisted JG with obtaining ethics approval at McMaster University
- SB assisted JG with the analysis and interpretation of the data
- SB provided critical feedback on previous drafts of the manuscript
- SB revised the article and approved of the final version of the manuscript before submission to the *Journal of Sport & Exercise Psychology*

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Role of co-author in Study 2:

- SB reviewed and refined the study design and obtained funding
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- Conceived the research question and study design
- Author of ethics application at McMaster University
- Contributed to study design and measure selection
- Lead investigator responsible for data collection, analysis and interpretation
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Role of co-author in Study 3:

- SB provided feedback about the study design and obtained funding
- SB assisted JG with obtaining ethics approval at McMaster University
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CHAPTER 1:

INTRODUCTION

1.1 SELF-REGULATION, SELF-CONTROL AND EXECUTIVE FUNCTIONING

1.1.1 Definitions

The term self-regulation broadly refers to processes (both automatic and controlled) within a system that uses information about its current state and compares it towards a desired state, standard, or goal (Carver & Scheier, 1998). At an unconscious or automatic level the body is continuously regulating itself to maintain various physiological states such as those systems that regulate body temperature and heart rate. Although these systems are essential for survival they typically operate out of human consciousness. From a controlled (and largely conscious) perspective, however, humans regulate their actions and behaviours continuously over the course of a day to maintain healthy diets and regular physical activity patterns, as well as towards work and school achievement (Hofmann, Vohs, & Baumeister, 2012). These conscious controlled processes of self-regulation can include, self-monitoring, planning, forming intentions, and goal setting (e.g., Abraham & Michie, 2008).

The conscious, controlled perspective of self-regulation is one in which the term self-control, colloquially known as “willpower”, is best represented when behaviour is being altered (Carver & Scheier, 2011). Specifically, self-control refers to conscious, deliberate and effortful processes, such as resisting temptations and controlling one’s emotions that regulate behaviour toward the attainment of a goal or standard (Baumeister Vohs, & Tice, 2007). Self-control is engaged in the self-regulation process when the current state is being altered towards a desired state (Baumeister, 2014). Therefore, self-control is a subset of self-regulation and refers to the self's capacity to override a behaviour, thought, or emotion and replace it with another.

Together, the importance of self-regulation and self-control for adaptive human functioning cannot be overemphasized. For example, the ability to alter behaviour in the service of future goals allows people to restrain short-term desires to reap long-term benefits, suppress selfish emotional and behavioural impulses, to sustain attention when minds would rather wander, work effectively in groups, and ultimately allow people to live longer, healthier, and more prosperous lives (Baumeister, Heatherton, & Tice, 1994; de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Mischel, et al., 2011; Mischel, Shoda, & Rodriquez, 1989; Tangney, Baumeister, & Boone, 2004). Yet, despite these advantages, self-control failures are common and are thought to be at the heart of many societal problems (Baumeister et al., 1994). Thus, understanding the potential mechanisms, such as physiological and psychological processes, that lead towards self-regulation successes and failures is of upmost importance.

Executive functioning refers to higher order top-down control processes originating within several brain areas that are responsible for the effective exertion of self-control (Lopez, Vohs, Wagner, & Heatherton, 2015). Self-control processes encompass the three basic forms of executive functioning including the maintenance and updating of relevant information (updating), mental set shifting

(shifting), and the inhibition of prepotent impulses (inhibition) (Hofmann, Schmeichel, & Baddeley, 2012). Updating is linked to working memory and refers to the ability to store and quickly retrieve information, while protecting this information from distractions. Shifting refers to the ability to switch back and forth between multiple tasks. Inhibition refers to the ability to deliberately prevent, or inhibit, dominant responses from being felt or acted upon that conflict with current goals or standards. Unlike updating and shifting, inhibition is thought to be at the heart of self-control as Baumeister and colleagues (1994) initially estimated that 80-90% of behavioural regulation consists of stopping a response. Indeed, research from an experience sampling study suggests that the average person spends approximately three to four hours a day deliberately inhibiting desires (Hofmann, Baumeister, Forster, & Vohs, 2012). Thus, the underlying neural networks encompassing executive functioning, primarily inhibition, are important to consider when investigating the mechanisms that contribute to successful self-regulation and self-control.

1.1.2 Importance of self-regulation and self-control for health behaviours

Noncommunicable (chronic) diseases, such as cardiovascular disease, cancer and diabetes, kill approximately 38 million people each year and cost health care systems billions of dollars (World Health Organization, 2015a). With the steady increase in the rate of diagnosis it becomes even more important to learn how to control these diseases through cost-effective interventions such as physical activity. While the source of several diseases may be unknown, there are several diseases that can be attributed to poor life choices (e.g., eating unhealthy food, overeating, smoking, sedentary behaviour). Furthermore, when individuals are managing these diseases, poor life choices also contribute to the progression of the disease (e.g., not adhering to their doctor’s orders, not abstaining from inappropriate behaviours that exacerbate the disease, physical inactivity). Thus, it is not surprising that the processes underlying self-regulation and self-control have been of particular interest to many areas of research investigating health behaviours (e.g., Baumeister et al., 1994; Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

Self-regulation and self-control involve dynamic processes when regulating various health behaviours. For instance, the goal of maintaining a healthy diet (intention forming) requires the purchasing of healthy foods (planning), maintaining the recommended consumption of various food groups (self-monitoring) and ultimately the exertion of self-control over not eating unhealthy junk food (inhibition). In many instances people can effectively engage self-control processes towards the effective self-regulation of behaviour, however despite their good intentions people often fail to self-regulate effectively (Baumeister et al., 1994). Thus, many research endeavours have utilized various theories of self-regulation such as social cognitive theory (e.g. Bandura, 2005; Clark, Gong, & Kaciroti, 2014), temporal self-regulation theory (Hall & Fong, 2007), control theory (see Michie et al., 2009), and the strength model of self-control (Baumeister, 2014) when trying to understand various health behaviours.

The notion that self-regulation and self-control are important constructs to target when understanding behaviour has been advocated for several decades (e.g., Bandura, 1986; Bandura & Mischel, 1965; Freud, 1946; Mischel, 1973). However, the amount of research dedicated to understanding self-regulation and self-control has exponentially increased over the last decade (see Figure 1 in Inzlicht & Schmeichel, 2015). With the advancement of many theories of self-regulation and self-control came the understanding that numerous physiological and psychological processes play important dynamical roles that contribute to self-regulation/self-control success and failure (e.g., Baumeister, 2014). Thus, when conducting research on self-regulation and self-control it is important to consider how physiological and psychological processes may interact and influence behaviour.

1.1.3 Importance of self-regulation and self-control for physical activity and exercise

It is important to note here that the increase in noncommunicable diseases over the past half century has been accompanied by a decline in population physical activity levels making physical inactivity one of the ten highest risk factors for global mortality (World Health Organization, 2015b). Higher physical activity levels are associated with reduced all-cause mortality from noncommunicable diseases (Warburton, Nicol, & Bredin, 2006). However, consistent with many other positive health behaviours, engaging in routine physical activity requires the continued self-regulation over a complex series of behaviours (e.g., organizing equipment, scheduling exercise sessions, managing barriers such as weather) as well as momentary self-control exertion (e.g., overcoming fatigue to continue exercising, resisting tempting alternatives such as socializing with friends) (e.g., Michie et al., 2009). Thus, research dedicated to understanding the self-regulation and self-control processes underlying physical activity behaviour is not only important for initiating and maintaining physical activity behaviours, but also for engaging in physical activity behaviours at recommended intensities.

Importantly, accumulating research suggests that targeting the brain areas governing self-regulation, self-control, and executive functioning are important for supporting the underlying neural networks involved in the cognitive control of physical activity behaviour (e.g., Buckley, Cohen, Kramer, McAuley, & Mullen, 2014). For instance, less developed or poorer functioning neural networks associated with executive function, self-regulation, and self-control processes are thought to contribute to sedentary behaviour. Indeed, several studies have shown that individuals who display greater executive functioning abilities engage in higher levels of physical activity (e.g., Daly, McMinn, & Allan, 2015; Hall, Fong, Epp, & Elias, 2008) and use more self-regulations strategies to adhere to their physical activity routines (e.g., McAuley et al., 2011). Furthermore, those with more developed executive control networks (i.e., areas associated with self-regulation and self-control) engage in physical activity more consistently which in turn strengthens the executive control network itself (for a review see Hall & Fong, 2015).

Although it is evident that higher levels of physical activity are associated with many positive health behaviours and even have the potential to improve the underlying executive control networks associated with successful self-regulation and self-control, physical inactivity rates in many countries have been steadily increasing (e.g., Warburton, Katzmarzyk, Rhodes, & Shephard, 2007). Thus, a greater understanding of the causal networks underlying executive control networks that are associated with self-regulation and self-control is needed to help understand why people fail to engage in regular physical activity or are unable to adhere to their planned routines.

1.2 CONTROL THEORY

Several theories and models have been advanced explaining the processes underlying self-regulated behaviour; however one very influential perspective is control theory (Carver & Scheier, 1998; Powers, 1973). Control theory proposes self-regulation occurs as a cybernetic behavioral feedback loop (depicted in Figure 1) that consists of four main elements: an input function, a reference value, a comparator, and an output function. From a very basic perspective, the input function serves to bring information into the loop based on the current state of the individual in regards to the target behaviour, the reference value (or desired state) is a goal or standard used by the comparator to evaluate the current state relative to the desired state, and the output function is the result of that comparison.

1.2.1 Role of self-regulation and self-control in control theory

The behavioural feedback loop also consists of two important phases: the "monitoring" phase and the "operation" phase. In the monitoring phase, people self-regulate their behaviour by using environmental and internal (i.e., affective and physiological) feedback to evaluate their current state relative to the reference value or standard (i.e., the desired state). When a discrepancy is detected between the current and desired states the operation phase is engaged in the attempt to reduce or eliminate the discrepancy. If feedback monitoring from the comparator shows the current state is at, or above, the desired standard (high feedback) then self-control operations are not engaged and resources necessary to alter behavioural control are conserved resulting in a "coasting" effect. However, if the comparator detects that the current state is below the desired standard (low feedback) self-control resources are expended in an effort to change behaviour in order to reduce or eliminate the discrepancy. Once feedback indicates the discrepancy has been eliminated, self-control operations are withdrawn; at least until another discrepancy is detected.

The processes involved in the behavioural feedback loop of self-regulation with regards to exercise performance may be illustrated using an example of a marathon runner. While performing a marathon, a runner will typically pace his or her running speed based on each kilometer (or mile) completed, especially during the initial stages of the race, in order to achieve a desired standard or to break a previous personal record. Pacing also occurs so that runners can regulate accumulating physiological energy demands so that they do not wear themselves out prior to the termination of the race and to conserve energy for a final sprint, if necessary. Consider a runner who is trying to maintain a pace of five minutes per kilometre. She completes the first kilometre in five minutes (i.e., current state) which is consistent with her goal (i.e., desired state) and, as a result, she maintains her pace (i.e., the comparator signals no change in the output) and the monitoring phase continues. After the second kilometre her split time is four minutes and 45 seconds which is 15 seconds faster than the goal of five minutes, which signals high feedback within the feedback loop. High feedback engages the operation phase triggering the conservation of resources and as a result the runner slows her running speed to conserve energy. At the end of the third kilometre, her split time is five minutes and 15 seconds which is 15 seconds slower than the goal of maintaining five minute kilometres (i.e., low feedback). Low feedback engages the operation phase triggering the exertion of self-control resources and as a result the runner exerts additional physical effort to increase her running speed in order to eliminate the discrepancy.

Although the marathoner provides a hypothetical example, it illustrates the dynamic processes involved with regards to self-regulation and self-control found within the behavioural feedback loop of control theory. It is important to note that self-control resources are, typically, only engaged when individuals fall short of their goal (low feedback) and conscious effort is required to reduce the discrepancy between the current and desired state. Indeed, it is not uncommon practice for athletes and exercisers to pace themselves in various sport and exercise settings to make it through a grueling workout or training session, or to achieve desired times in prolonged races while ensuring that their physiological limits are not surpassed until the end of the session (e.g., Jones et al., 2013). Thus, control theory provides a viable framework for understanding the self-regulation of sport and exercise behaviour.

1.2.2 Limitations of control theory

Control theory has successfully been applied in many health settings when trying to understand the self-regulation of behaviour, such as nutrition and physical activity (for a review see Michie et al., 2009), however it does not adequately account for why, in many circumstances, people fail to self-regulate efficiently (Baumeister et al., 1994). This lack of evidence is primarily due to the focus, by early researchers, that was placed on understanding the importance of the monitoring phase for goal setting and other self-monitoring strategies and as a result the operation phase did not receive a great deal of attention (Baumeister, 2014). Research dedicated to understanding the processes within the operation phase has emerged more recently and was highly influenced by the development of the strength model of self-control which integrates an energy perspective on self-regulation and self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister et al., 1994; Baumeister, Vohs, & Tice, 2007; Baumeister, 2014).

1.3 STRENGTH MODEL OF SELF-CONTROL

The focal feature of the strength model is self-control strength. Self-control strength is conceptualized as a central nervous system resource that is depleted when an individual uses self-control to regulate (or control) thoughts, emotions, or behaviours that require self-control resources (i.e., executive function resources, Hofmann, Schmeichel, & Baddeley, 2012). The theoretical basis of the strength model was originally structured around several primary assumptions: (1) self-control strength is necessary for executive functioning, (2) human beings have a limited resource (strength) that governs the ability to execute acts requiring self-regulation and self-control, (3) when self-control strength is depleted, the ability to exert self-control on other tasks becomes impaired, (4) acts of self-control whether they involve emotional, behavioural, or cognitive control, all draw upon the same limited resource pool, (5) during acts of self-regulation the body begins to alter or conserve its responses before the resource pool becomes fully depleted, (6) replenishment of self-control strength resources can be achieved through rest and possibly other mechanisms, (7) there are likely individual differences with regards to trait self-control capacities and some people will have a larger pool of resources to draw upon (or are more resilient to self-control depletion), and (8) systematic and frequent exertion of self-control should train/strengthen self-control strength increasing one's capacity to self-regulate (Muraven & Baumeister, 2000).

According to the strength model, self-control processes that are engaged during the operation phase of the behavioural feedback loop, proposed by control theory, rely on a limited energy source. When these self-control resources have been depleted by previous demands, the ability to self-regulate behaviour towards the desired standard is compromised. It is critical to note here that the strength model is primarily focused on what happens during the operation phase following low feedback when the current behaviour or state is below the desired standard and self-control resources are needed to reduce the discrepancy. Whereas when behaviour is above the standard (high feedback) self-control strength resources are conserved. Thus, the strength model proposes that when people fail to self-regulate effectively it is primarily due to their inability to draw upon self-control resources that were depleted by prior self-control demands.

To illustrate the concept of self-control strength regulation, consider a dieter who successfully adheres to his diet on routine work days, but fails to inhibit the temptation of eating unhealthy junk food during long and emotionally demanding days at work. For the dieter, expending self-control energy dealing with the emotional demands of work leaves fewer resources to apply to dieting. Similarly, even if someone effectively self-regulated their actions towards their goal of exercising after work, by bringing their workout equipment to the office and planning to exercise with a colleague, their ability to effectively engage in the planned workout session may be affected by extensive self-control demands during the workday. As a result of having fewer self-control resources to draw upon this individual may exercise at a lower intensity than desired, prematurely end the workout, or even choose not to engage in the exercise session altogether. Thus, the strength model presents a unique conceptual framework for understanding why self-control and self-regulation failures arise.

1.3.1 Support for the strength model

There is now extensive evidence supporting many of the original assumptions of the strength model spanning several domains of research and health behaviours including abstaining from aggression and inappropriate sexual behaviours as well as eating healthy and managing emotions (for a meta-analysis see Hagger, Wood, Stiff, & Chatzisarantis, 2010). In these studies and others, findings supported the strength model's underlying idea that exerting self-control for a prolonged period of time (e.g., controlling one's emotions) leads to reductions in subsequent self-control performance (e.g., persistence on unsolvable anagrams). Research also supports predictions of the strength model relating to trait self-control showing that those higher in trait self-control are more successful in many areas of life requiring self-control such as school and work achievement and interpersonal functioning (for a meta-analysis see de Ridder et al., 2012).

The strength model has captured the interest of researchers in the area of sport and exercise for almost a decade. Initial research by Bray, Martin Ginis, Hicks, and Woodgate (2008) showed that after participants performed an incongruent Stroop task (a cognitive task known to require executive function resources) they showed impaired physical stamina to perform an isometric handgrip endurance task. Several other studies have shown that performing tasks that require the exertion of self-control over emotions (e.g., Wagstaff, 2014) and thoughts (e.g., Graham, Sonne, & Bray, 2014) also lead to reductions in subsequent attempts to regulate endurance performance.

Recent research has extended research investigating simple muscular endurance tasks to more traditional exercise behaviours such as endurance cycling (Martin Ginis & Bray, 2010; Wagstaff, 2014) and endurance running (Pageaux, Lepers, Dietz, & Marcora, 2014). However, only one study has investigated the effects of self-control depletion on endurance performance for exercise tasks requiring strength (i.e., press-ups and sit-ups, Dorris, Power, & Kenefick, 2012).

Furthermore, studies have shown that prior exertion of self-control also lead to reductions in performance on skill-based tasks requiring accuracy (e.g., McEwan, Martin Ginis, & Bray, 2013) and reaction time (Englert & Bertrams, 2014). Other research in sport and exercise settings have shown impairments following self-control depletion in participants' abilities to manage distractions (Englert, Bertrams, Furley, & Oudejans, 2015), regulate attention (Englert, Zwemmer, Bertrams, & Oudejans, 2015), make decisions (Furley, Bertrams, Englert, & Delphia, 2013) as well as for performance on tasks assessing manual dexterity and fine motor control (e.g., Duncan, Fowler, George, Joyce, & Hankey, 2015).

Research has also shown that self-control depletion influences other factors relating to sport and exercise such as planned exercise intensity (Martin Ginis & Bray, 2010). In addition, low levels of trait self-control have been shown to be related to heightened attitudes and intentions toward using prohibited performance-enhancing drugs among competitive athletes (Chan et al., 2015). Thus, there is accumulating evidence supporting the utility of the strength model with regards to understanding self-regulation and self-control failures in sport and exercise settings.

1.3.2 Physiological and psychological mediators of the strength model

Since the development of the strength model, researchers spanning many areas of expertise within psychology, neuroscience, and physiology have investigated factors that could help explain why self-control performance suffers following the exertion of self-control and possible ways that people can overcome the debilitating effects of strength depletion. Given that self-control failures are at the heart of many behavioural problems (Baumeister et al., 1994), understanding these factors in highly controlled laboratory settings is important for evaluating effects that can be applied in larger interventions targeting behaviour change.

Some of the more prominent physiological factors involved in the self-control depletion – performance relationship include cardiovascular responses (e.g., Segerstrom & Solberg Nes, 2007; Wright, Stewart, & Barnett, 2008), muscle activity (e.g., Bray et al., 2008; Graham et al., 2014), self-control strength training (for reviews see Baumeister, Gailliot, DeWall, & Oaten, 2006; Friese, Hofmann, & Wiers, 2011), and brain glucose availability or allocation (Beedie & Lane, 2012; Gailliot et al., 2007). Importantly, recent evidence shows depletion of self-control corresponds with several neurophysiological processes relating to cerebral blood flow, as shown in functional magnetic resonance imaging (fMRI) research (e.g., Lopez et al., 2015; Wagner & Heatherton, 2013). Although no underlying physiological mechanisms were measured in the studies presented within this dissertation it is important to highlight the fact that several neurophysiological processes are involved in the self-control depletion – performance relationship that may contribute to interoceptive sensations that affect various psychological states. Indeed, findings from the dissertation studies support this notion and will be explained throughout.

Some of the more prominent psychological factors involved in the self-control depletion – performance relationship include shifts in affect (Egan, Clarkson, & Hirt, 2015; Tice, Baumeister, Shmeuli, & Muraven, 2007) and cognitive-motivational processes such as cost-benefit analyses or opportunity costs (Inzlicht, Schmeichel, & Macrae, 2014; Kurzban, Duckworth, Kable, & Myers, 2013), as well as the strategic conservation of self-control resources (e.g., Muraven, Shmueli, & Burkley, 2006). One psychological construct which has been found to play an influential role in the effective self-regulation of behaviour is self-efficacy (Bandura, 1997; Bandura, 2012), yet it has received very little attention in the self-control strength literature (Hagger et al., 2010) and has only recently been shown to be negatively affected by self-control depletion for *cognitive* task performance (Chow, Hui, & Lau, 2015). Thus, research is needed to further investigate self-efficacy's role within the self-control depletion – *physical* performance relationship.

1.3.3 Limitations of the strength model

Although the strength model has provided an elegant account for why attempts to exert self-control may fail in the operation phase of control theory, the research focusing on the strength model has solely focused on self-control failures within the operation phase without considering how self-control depletion may affect other aspects of the control theory framework. For instance, control theory predicts that high feedback leads to a coasting effect and the conservation of self-control resources whereas low feedback leads to the exertion of self-control to reduce the discrepancy. However, a relevant question pertains to how do different types of feedback influence behaviour when self-control resources are depleted.

Contemporary revisions to the strength model (Baumeister, 2014) highlight that, when self-control resources are depleted, individuals will make greater attempts to strategically manage subsequent resource exertion and instead are more likely to conserve these finite resources. Therefore, it is plausible that people may alter their allocation of self-control resources in response to performance feedback differently when they are depleted compared to when they are not. For example, when self-control resources are depleted, high feedback may trigger greater withdrawal of resources because there is a greater need for conservation. In a similar manner when people are depleted of self-control resources, low feedback may show the opposite effect in comparison to when people are not depleted as the need for resource conservation may override attempts to increase performance.

The idea that self-control resource allocation may be altered following feedback and depletion has theoretical relevance in terms of understanding cognitive and behavioral processes through which feedback may be interpreted and acted upon. This idea also has practical relevance with regards to sport and exercise behaviour as many sustained or repetitive behaviours involved in sport training or fitness-related exercise may last lengthy periods of time and require ongoing self-control operations that do not allow self-control strength resources to fully recover until the session is completed. Thus, further research is needed to investigate whether performance feedback leads to different outcomes when one is depleted of self-control strength

Although the strength model has been the dominant theoretical view of self-regulation over the past 15 years, the assumption that self-control relies on some finite energy or limited internal resource, as well the biological origin of this resource has recently come under enhanced scrutiny (Beedie & Lane, 2012; Inzlicht & Schmeichel, 2015; Inzlicht et al., 2014; Kurzban et al., 2013). Researchers arguing against a limited resource perspective suggest that when people have exerted self-control they engage a decision making process that ultimately results in an unwillingness to exert further self-control resources rather than being unable to exert self-control due to resource depletion.

For example, Kurzban et al. (2013) suggest that the subjective experience of increased effort and fatigue arising from prolonged self-control exertion activates motivational-cognitive processing, in the form of cost-benefit analyses, for continued self-control exertion which results in an unwillingness to sustain task performance. As a result of the cost-benefit analyses outcome Kurzban et al. (2013) suggest that self-control resources are reallocated to other tasks that are perceived as more valuable to the individual. Similarly, Inzlicht and Schmeichel (2015) also suggest that the effortful and aversive nature of exerting self-control leads to motivational-cognitive processing in the form of reduced task motivation which results in an unwillingness to exert further self-control shifting priorities to more gratifying desires. As a result, and rather than depleting a hypothetical resource, prolonged self-control exertion causes a reallocation of effort to tasks people prefer to engage in rather than those they feel pressured to perform.

The arguments against the limited resource account of the strength model are supported by studies showing that people can overcome self-control depletion effects when they are offered rewards, interpersonal incentives, or when they are intrinsically motivated (e.g., Muraven & Slessareva, 2003; Moller, Deci, & Ryan, 2006). Further research has shown that depletion effects can be overcome through shifts in positive affect (e.g., Egan et al., 2015; Tice, et al., 2007). However, it is critical to note that shifts in positive affect did not lead to changes in motivation in the above studies. Furthermore, there has been no support for the motivational account of depletion when motivation was not manipulated (see Baumeister, 2014; Baumeister & Vohs, 2014). Importantly, studies have shown that increased motivation leads to enhanced self-control performance only in the short-term and increased motivation ultimately leads to reduced performance over successive acts of self-control (Vohs, Baumeister, & Schmeichel, 2012; Graham, Bray, Martin Ginis, 2014).

These findings lead to recent revisions of the strength model highlighting the importance of motivational-cognitive processes that occur following self-control depletion and that depletion ultimately motivates the need to conserve limited self-control resources (Baumeister, 2014). Nevertheless, it is clear that performances following self-control depletion are not solely based on limited resources, suggesting other psychological variables, such as increased states of (subjective) fatigue (Baumeister, 2014), warrant further investigation alongside shifts in motivational-cognitive processes.

Another argument against the strength model is that it lacks a theoretical basis regarding the mechanisms that lead to changes in psychological processes following self-control depletion as well as how their effects can negatively, or positively, influence subsequent self-controlled performances (Inzlicht & Schmeichel, 2015). Researchers recognize that self-control depletion results in increased subjective fatigue, possibly triggering resource conservation (Baumeister, 2014), and that this subjective experience of fatigue results in an unwillingness to exert subsequent self-control motivating resource allocation to other tasks (Inzlicht & Schmeichel, 2015; Kurzban et al., 2013). However, it is plausible that there may be other intermediary psychological processes that occur following increases in subjective fatigue.

One process that may play such an intermediary role is self-efficacy. Self-efficacy refers to the “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Self-efficacy theory (Bandura, 1997) proposes that increased subjective fatigue leads to reductions in self-efficacy. Based on this argument, it is plausible that increased subjective fatigue leads to reduced self-efficacy which may be an antecedent to resource conservation and reduced motivation as people feel less confident in their abilities to exert self-control to meet subsequent task demands. Thus, reduced self-efficacy as a result of increased subjective fatigue presents a theoretical account for the mixed evidence following self-control depletion, which warrants future research.

Although there are controversies in the literature with regards to whether self-control is dependent upon limited resources, researchers acknowledge that the prolonged exertion of self-control is often aversive and may induce an increased state of subjective fatigue (Baumeister, 2014; Hagger et al., 2010; Inzlicht & Schmeichel, 2015; Kurzban et al., 2013). However, as discussed above, theorizing pertaining to the effects of increased subjective fatigue following self-control depletion on subsequent performance remains unclear. For instance, self-efficacy theory (Bandura, 1997) would predict that subjective fatigue plays an active role mediating the self-control depletion – performance relationship whereas other theorists suggest subjective fatigue plays a passive role merely indicating a state of self-control depletion (Baumeister, 2014). Thus, research is needed to further understand the physiological and psychological causal mechanisms leading to self-regulation and self-control successes/failures.

Furthermore, while there is some evidence showing that ratings of subjective fatigue are higher following self-control depletion manipulations (d = 0.44, Hagger et al., 2010), it is critical to note that the studies reviewed in Hagger et al.'s meta-analysis (2010) assessed subjective fatigue haphazardly; typically using single-item measures developed by the study authors (e.g., Baumeister, et al., 1998, Studies 1 and 4; Friese, Hofmann, & Wanke, 2008; Studies 2 and 3). However, the State Self-Control Capacity Scale (SSCCS) developed by Ciarocco, Twenge, Muraven and Tice (2004) operationalizes subjective (self-control) fatigue using a collection of items that correspond with various descriptive forms of fatigue states. For example, items include "*I feel drained*", *"I feel mentally exhausted", "I feel worn out", and "I want to give up"*. Thus, future research using more a refined indication of fatigue, such as the SSCCS, is needed to assess whether increased subjective fatigue mediates the self-control depletion – performance relationship.

1.4 SELF-EFFICACY THEORY

A considerable body of evidence shows that self-efficacy plays an influential role, as a motivational perception guiding behaviour, determining the successful self-regulation of various health behaviours such as eating healthy and sport and exercise (e.g., Bandura, 1997; Moritz, Feltz, Fahrback, & Mack, 2000). In particular, self-efficacy is theorized to influence the activities and challenges people choose to pursue. Importantly, when established goals (or standards) become threatened we draw on self-efficacy beliefs to inform our decision of how much effort and persistence to put forth towards goal attainment. Thus, self-efficacy is an important psychological construct to consider when examining the self-regulation of sport and exercise behaviour and performance as many exercise behaviours require the continued exertion of effort and persistence.

1.4.1 Sources of self-efficacy

Self-efficacy theory (Bandura, 1997) proposes self-efficacy beliefs are constructed from four primary sources of information including mastery experiences, vicarious experiences, verbal persuasion, and physiological/affective states. Importantly, these sources can either positively or negatively influence self-efficacy based how people cognitively process and evaluate the input.

Prior mastery experiences are viewed as the most influential source of self-efficacy as they provide “the most authentic evidence of whether one can muster whatever it takes to succeed” (Bandura, 1997, p. 80). Successful task performance typically enhances self-efficacy whereas unsuccessful task performance undermines self-efficacy. However, it is important to note that in order for task performance to affect self-efficacy it must be cognitively processed and evaluated before it can affect subsequent performance. For instance, when task failure is attributed to not trying hard, rather than a lack of ability, self-efficacy can actually increase which, in turn, motivates persistence to exert further resources on a subsequent task to make up for the poor performance. In contrast, success achieved through a high degree of effort has the potential to lower self-efficacy beliefs to muster the same degree of effort on a subsequent task (Bandura, 1997, p. 84). Thus, prior mastery experiences and the cognitions that arise following task success and failure are important to consider when assessing self-efficacy’s role in the self-regulation of behaviour.

Vicarious experiences involve watching others (i.e., models) perform a task, imagining oneself perform a task (i.e., through mental imagery), and interpreting the processes involved and outcomes (success/failure) in relation to one’s own experiences. Vicarious experiences are thought to enhance self-efficacy through successful performances, in other words, if someone views a model (or oneself through imagery) successfully completing a task then his/her self-efficacy for that task also increases. However, it is important to note that vicarious experiences also operate through social comparison with regards to normative performance standards. When people outperform others, their self-efficacy increases whereas being outperformed typically lowers self-efficacy.

Verbal persuasion influences efficacy beliefs through the feedback provided from others. For instance, positive encouragement ("good job") and competence-related feedback ("you did awesome") enhance self-efficacy whereas negative evaluations of performance reduce self-efficacy. Although verbal persuasion is common in many sport and exercise settings its proposed effects on self-efficacy are weaker than both mastery and vicarious experiences (Wise & Trunnel, 2001).

The final source(s) of self-efficacy are affective and physiological states. Affective and physiological states are particularly important for influencing self-efficacy when the tasks performed are of physical nature (Bandura, 1997). The influence of physiological information on self-efficacy is highly dependent on the way that it is appraised. For instance, when performing physical tasks, people take notice of their levels of subjective fatigue, anxiety, aches, pains, and uncertainly as indicators of physical inefficacy (Bandura, 1997, p. 106). As highlighted above in the limitations of the strength model subsection (section 1.3.3), tasks that require self-regulation and self-control often result in increased states of subjective fatigue. Thus, increased states of subjective fatigue are likely to negatively influence self-efficacy and mediate the negative change in subsequent performance on tasks requiring self-control, providing a theoretical account for the negative effects of self-control depletion. However, this premise has yet to be investigated.

1.4.2 Role of self-efficacy within control theory

Although self-efficacy was not originally theorized as a psychological construct influencing self-regulated behaviour within control theory, recent research has attempted to examine its causal role. Based on control theory, Vancouver and colleagues (e.g., 2002; 2014) and others (for a meta-analysis see Sitzmann & Yao, 2013) have investigated the effects of feedback on self-efficacy and performance for tasks performed in succession. Their results showed that high feedback about performance on the earlier tasks led to high self-efficacy but a reduction in performance, whereas low feedback led to lower self-efficacy and an increase in performance. In short, the effects of feedback on self-efficacy were those predicted by self-efficacy theory; however, feedback affected performance in line with the predictions of control theory. These findings led those researchers to suggest that self-efficacy has a negative or null effect on performance over successive tasks, and rather than being a driver of future performance, self-efficacy is more a product of past performance.

Bandura (2012; 2015) has criticized the negative self-efficacy – performance relationship proposed by many control theorists on several grounds, but primarily with regards to how self-efficacy has been operationalized and measured in several studies. Based on Bandura’s recommendations for measurement (1997; 2006), task self-efficacy represents the beliefs in one's abilities to perform specific tasks and should be assessed with individual items representing hierarchical gradations of task performance using a scale ranging from 0 (not confident) to 10 (totally confident). These procedures were not used in the majority of studies reviewed by Sitzmann & Yao (2013); rather self-efficacy was often inferred through assessments of previous task performance and generalized self-efficacy using a range of bipolar scales. Thus, the role of self-efficacy within control theory remains inconclusive and further research is needed to adequately assess self-efficacy's role based on Bandura's (2006) recommendations for measurement.

1.4.3 Role of self-efficacy within the strength model

Although self-efficacy was not originally proposed as a psychological construct within the strength model of self-control, attempts have been made to investigate self-efficacy's role in affecting behaviour following self-control depletion. Unfortunately, as was the case with control theory, self-efficacy has been operationalized in ways that are not consistent with Bandura's (1997) conceptual definition and recommendations for measurement (Bandura, 2006). For example, in several studies, self-efficacy was inferred through assessments of how participants felt they had performed on a previous self-control task and through assessments of generalized self-efficacy following self-control depletion (e.g., Englert & Bertrams, 2014; Finkel, Dalton, Campbell, Brunell, Scarbeck, &

Chartrand, 2006; Wallace & Baumeister, 2002) leading researchers to conclude that self-efficacy is not associated with self-control strength depletion. However, recent research (Chow et al., 2015) has assessed self-efficacy based on Bandura's (2006) recommendations for measurement.

In a series of studies involving cognitive self-control task performances, Chow et al. (2015) showed that participants consistently rated lower task self-efficacy after they completed tasks designed to deplete self-control and that changes in self-efficacy partially mediated the effect of self-control depletion on cognitive self-control performance (Studies 2 and 3). These findings are very intriguing as they are consistent with the arguments above (in section 1.3.3 – limitations of the strength model) suggesting that self-efficacy may play an influential role in the self-control depletion – performance relationship as a potential antecedent to changes in motivational-cognitive processes following depletion. However, one limitation of Chow et al.'s (2015) findings is that motivation was not assessed so it is unclear if reduced self-efficacy leads to reductions in motivation to exert further self-control or if reduced self-efficacy is merely an indicator of self-control depletion.

Although Chow et al.'s (2015) findings provided support for self-efficacy's potential role in the self-control depletion – performance relationship accounting for the negative change in performance following depletion; it remains unclear why self-efficacy is reduced. Based on the proposed sources of self-efficacy (Bandura, 1997) and, given that Chow et al. (2015) did not manipulate prior mastery experiences or vicarious experiences, and that there were no differences in affect following depletion, a change in participants' physiological state is a likely candidate for reduced self-efficacy.

As previously discussed in section 1.3.2 (physiological and psychological mediators of the strength model), there are several physiological changes that occur following depletion that may account for changes in self-efficacy. For instance, changes in cerebral blood flow (Lopez et al. 2015) and within the autonomic nervous system (i.e., reductions in heart rate variability; Segerstrom & Solberg Nes, 2007) may result in an interoceptive feeling state reflecting a specific form of tiredness or subjective fatigue. As discussed briefly above in section 1.3.3 (limitations of the strength model), the physiological changes brought on by self-control depletion may be associated with sensations of (subjective) fatigue and increased perceptions of subjective fatigue may be an antecedent to self-efficacy which in turn may influence motivational-cognitive processes that affect subsequent self-control performance. This sequential, causal, psychophysiological pathway is consistent with theorizing found within self-efficacy theory (Bandura, 1997), however further research is needed to assess these pathways following self-control depletion.

1.5 GENERAL PURPOSE OF DISSERTATION

To summarize, self-regulation, self-control, and executive functions are interconnected and dynamical processes that are related to several adaptive health behaviours, including sport and exercise. However, in many instances people are unable to effectively self-regulate their behaviour. Many theories have been advanced to explain the self-regulation and self-control of behaviour. Two dominant theories include control theory (Carver & Scheier, 1998, 2011) and the strength model of self-control (Baumeister, 2014).

Control theory proposes self-regulation occurs as a cybernetic behavioral feedback loop (depicted in Figure 1) that consists of two phases, the monitoring phase and the operation phase, which attempt to maintain consistency between the current behavioural state and desired (standard) state. When the monitoring phase detects a discrepancy between the current and desired states (high and low feedback) the operation phase is engaged and self-control resources are either conserved (following high feedback) or exerted (following low feedback) to reduce the discrepancy. However in many instances the operation phase fails to reduce discrepancies following low feedback (Baumeister et al., 1994).

The strength model (Baumeister et al., 1998; Baumeister, 2014) was developed to address this limitation of control theory and suggests that self-control strength resources are dependent on a finite internal resource. Recent criticisms against the limited resource account of the strength model have proposed that self-control failures occur due to shifts in motivational-cognitive processing following prolonged exertion of self-control rather than due to limited resources to draw upon (Kurzban et al., 2013; Inzlicht & Scmeichel, 2015).

Self-efficacy plays an influential role in effective self-regulation and self-control of behaviour (Bandura, 1997; Bandura, 2012), yet it has been largely ignored as a potential psychological construct within control theory and the strength model of self-control. Based on the arguments above, this dissertation seeks to address several limitations of previous research when attempting to integrate self-efficacy theory into control theory and the strength model. Specifically, this dissertation seeks to evaluate the role that self-efficacy plays an integral role, as a motivational perception guiding behaviour, for understanding the processes leading to self-regulation success and failures. Although feedback and self-control strength resources are integral components of control theory, no studies have investigated how these processes may interact with self-efficacy. Therefore, this dissertation sought to provide a more complete understanding of how the self-control depletion – physical performance relationship is mediated and moderated by motivational-cognitive processes (i.e., feedback and self-efficacy).

The overarching objective of this dissertation is to investigate the effects of self-control strength depletion on self-efficacy and physical exercise performance drawing from the strength model of self-control (Baumeister, 2014), self-efficacy theory (Bandura, 1997), and control theory (Carver & Scheier, 1998, 2011). The overall objective was pursued along three specific lines of inquiry. The first purpose was to address limitations regarding the improper measurement of self-efficacy when assessing its role following self-control strength depletion and expand the findings by previous research to physical self-control performances. Drawing from theorizing found within self-efficacy theory (Bandura, 1997), the second purpose was to investigate why self-efficacy is reduced following self-control depletion and test a serial mediation model predicting self-control depletion → increased subjective fatigue → reduced task self-efficacy → reduced resistance exercise performance. Drawing from theorizing found within control theory, self-efficacy theory, and the strength model of self-control, the third purpose was to investigate the independent and interactive effects of self-control strength depletion and performance feedback on self-efficacy and isometric handgrip endurance performance.

1.5.1 Study 1

Study 1 investigated the role of task self-efficacy as a psychological factor involved in the self-control depletion – physical endurance performance relationship. This study addressed a limitation of previous studies with regards to the improper measurement of self-efficacy (Bandura, 2006). Participants completed two isometric handgrip endurance trials, separated by a Stroop task, which was either congruent (control) or incongruent (causing depletion). Task self-efficacy for the second endurance trial was measured following the Stroop task. It was hypothesized that that task self-efficacy and physical self-control endurance performance would be negatively affected by self-control depletion. Given the strong and consistent relationship between self-efficacy and behavior (e.g., Bandura, 1997; Moritz et al., 2000), it was further hypothesized that task self-efficacy would mediate the effect of self-control depletion on task performance.

1.5.2 Study 2

Study 2 built on Study 1’s findings by investigating the role of task self-efficacy within the self-control depletion – performance relationship utilizing an exercise task that has not been previously investigated following self-control depletion, resistance exercise (i.e., seated bench press and leg extension). In addition, Study 2 sought to provide a theoretical account for why self-control depletion leads to reductions in self-efficacy. Based on Bandura’s theorizing (1997, p. 106), it is plausible that self-control depletion negatively affects performance through sequentially-mediated pathways involving subjective fatigue and task self-efficacy. Thus, this study investigated the effects of self-control depletion on subjective fatigue (assessed through the State Self-Control Capacity Scale: SSCCS), task self-efficacy, and endurance performance of resistance exercise. We tested a sequential mediation model predicting self-control depletion → reduced SSCCS → reduced task self-efficacy → reduced task performance. Participants performed one set of maximum repetitions on bench press (at 60% of one repetition maximum: 1RM) and leg extension (at 40% of 1RM) followed by either an incongruent (causing SC depletion) or congruent (no depletion) Stroop task. They then completed measures of SSCCS and task self-efficacy, followed by a second set of maximum repetitions. It was hypothesized that self-control depletion would lead to an increase in subjective fatigue (indicated by lower scores on the SSCCS), which then would negatively inform task self-efficacy, and in turn would lead to poorer physical self-controlled task performance (i.e., a reduction in repetitions on bench press and leg extension).

1.5.3 Study 3

Study 3 examined the independent and interactive effects of self-control strength depletion and normative performance feedback on task self-efficacy and self-controlled physical endurance. Participants performed two isometric endurance handgrip trials separated by a congruent (no depletion) or incongruent (depletion) Stroop task and a normative-based (high/low/no) feedback manipulation regarding their performance on the first handgrip trial. Based on previous findings (Graham & Bray, Studies 1 and 2), the first hypothesis was that self-control strength depletion would have negative effects on self-efficacy and task performance. Drawing from control theory (e.g., Carver & Scheier, 2011), it was predicted that high feedback would lead to lower performance than low feedback when participants were not depleted of self-control strength. Based on the premise that self-control resources may be more cautiously conserved when people are depleted (Baumeister, 2014), it was predicted task performance would be lower for both high and low feedback conditions compared to the no depletion conditions. Lastly, it was predicted that high feedback would lead to higher task self-efficacy and low feedback would lead to lower task self-efficacy in both the depletion and control conditions.

1.6 SUMMARY

Three controlled experimental laboratory studies were undertaken to test the role of self-efficacy (Studies 1-3) and feedback (Study 3), as motivational-cognitive processes that affect self-controlled behaviour, within the self-control depletion – physical performance relationship as well as within the control theory framework. These studies are presented in the subsequent three chapters, followed by a general discussion summarizing how this dissertation has contributed to the literatures of control theory, self-efficacy theory, and the strength model of self-control.

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Figure 1. Control theory's behavioural feedback loop of self-regulation

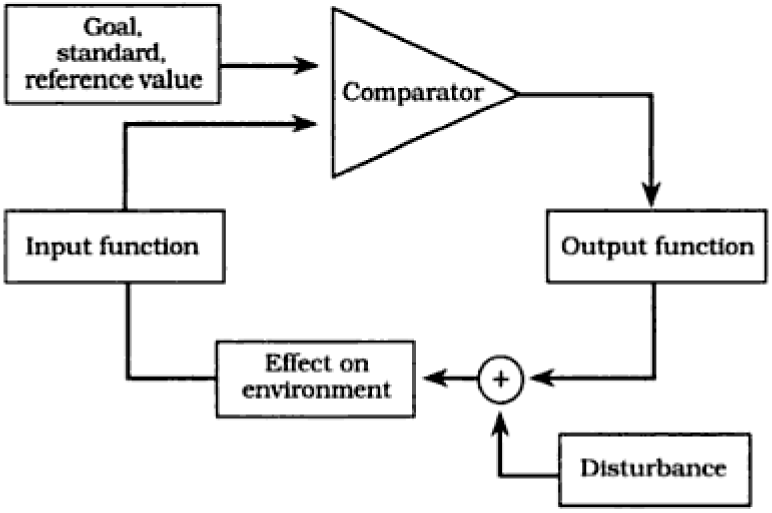

Figure 2.1. Schematic depiction of a feedback loop, the basic unit of cybernetic control. In such a loop a sensed value is compared to a reference value or standard, and adjustments are made in an output function (if necessary) to shift the sensed value in the direction of the standard.

Figure taken from Carver, C. S., & Scheier, M. F. (1998). On the self-regulation of behaviour (p. 11). New York, NY: Cambridge University Press. Used with permission from the Publisher.

CHAPTER 2

Self-control strength depletion reduces self-efficacy and impairs endurance exercise performance

Preamble

Self-control strength depletion reduces self-efficacy and impairs endurance exercise performance is the first study in the dissertation series. The study examines the role of task self-efficacy as a psychological factor involved in the self-control depletion – physical endurance performance relationship.

The following manuscript is currently in press at the *Journal of Sport & Exercise Psychology*. The word document version of the manuscript (formatted according to the *Journal of Sport & Exercise Psychology* author guidelines) is included in the dissertation as author proofs are not yet available.

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Contribution of Study 1 to overall dissertation

Study 1 provides the first evidence that task self-efficacy is negatively affected following self-control depletion when assessing physical self-control endurance performance. Findings from Study 1 also suggest that the negative change in task self-efficacy indirectly (mediates) accounts for the negative change in physical endurance performance following self-control depletion. Thus, Study 1 contributes to the overall dissertation by showing task self-efficacy is a potential psychological construct that should be investigated more thoroughly as a factor accounting for changes in physical endurance performance following self-control strength depletion.

Abstract

The purpose of this study was to investigate the role of task self-efficacy as a psychological factor involved in the self-control depletion – physical endurance performance relationship. Participants (*N* = 37) completed two isometric handgrip endurance trials, separated by a Stroop task, which was either congruent (control) or incongruent (causing depletion). Task self-efficacy for the second endurance trial was measured following the Stroop task. Participants in the depletion condition reported lower task self-efficacy and showed a greater reduction in performance on the second endurance trial when compared to controls. Task self-efficacy also mediated the relationship between self-control depletion and endurance performance. The results of this study provide evidence that task self-efficacy is negatively affected following self-control depletion. We recommend that task self-efficacy be further investigated as a psychological factor accounting for the negative change in self-control performance of physical endurance and sport tasks following self-control strength depletion.

Self-control strength depletion reduces self-efficacy and impairs endurance exercise performance

Self-regulation or self-control refers to the act of exerting control over one's behaviors, thoughts, and emotions to override instinctive or habitual responses and pursue long-term objectives (Baumeister, 2014; Mischel, 1996). Self-control is linked to many positive behavioral outcomes (Baumeister, Heatherton, & Tice, 1994) as well as sport and exercise performance (e.g., Dorris, Power, & Kenefick, 2012; Wagstaff, 2014). The strength model of self-control postulates that exerting self-control consumes an internal resource (executive resources, cf. Hofmann, Schmeichel, & Baddeley, 2012) that becomes depleted and induces a state referred to as "ego depletion" (Baumeister, Vohs, & Tice, 2007). Depletion of self-control strength leads to negative carryover effects on task performance within similar domains (e.g., physical-physical, Cohen's d = 0.59) as well as between dissimilar domains (e.g., cognitive-physical, d = 0.63) as long as the tasks performed require self-control (for a meta-analysis see Hagger, Wood, Stiff, & Chatzisarantis, 2010).

Sport and exercise science research has shown participants who exerted self-control over their thoughts or emotional responses for a brief period of time performed worse on subsequent physical endurance tasks (e.g., Graham, Sonne, & Bray, 2014; Wagstaff, 2014). Performance of skilled tasks involving dart throwing (e.g., McEwan, Martin Ginis, & Bray, 2013), basketball foul shooting (e.g., Englert, Bertrams, Furley, & Oudejans, 2015), and sprint-start reaction time (e.g., Englert & Bertrams, 2014a) is also impaired by prior self-control depletion. Thus, understanding psychological and physiological mechanisms leading to self-control depletion as well as factors that moderate or mediate the effects of self-control depletion on physical performance should be an area of attention for sport and exercise science researchers.

Beginning with the initial studies on the strength model of self-control (i.e., Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven, Tice, & Baumeister, 1998), researchers have investigated factors that could explain why task performance is negatively affected following self-control depletion as well as to understand how individuals can overcome the negative effects of depletion. These factors have included physiological processes such as brain glucose availability or allocation (e.g., Beedie & Lane, 2012; Gailliot et al., 2007), muscle activity (e.g., Bray, Martin Ginis, Hicks, & Woodgate, 2008), cardiovascular responses (e.g., Segerstrom & Solberg Nes, 2007), and self-control strength training (e.g., Bray, Graham, & Saville, 2015). Recent evidence shows depletion of self-control (or performing tasks that purportedly deplete self-control strength) corresponds with several neurophysiological processes relating to cerebral blood flow as shown in fMRI (Brass, Lynn, Demanet, & Rigoni, 2013; Wagner & Heatherton, 2013). Thus, a growing body of research has begun to explore a number of intermediary or mediating variables that may account for the effects of self-control depletion.

Although it is important to understand how self-control depletion affects physiological processes, psychological processes may also play important roles in the self-control depletion – performance relationship. Some of the psychological processes proposed include strategic conservation of self-control resources (e.g., Muraven, Shmueli, & Burkley, 2006) as well as shifts in affect (e.g., Egan, Clarkson, & Hirt, 2015; Tice, Baumeister, Shmeuli, & Muraven, 2007) and cognitive-motivational processes such as cost-benefit analyses or opportunity costs (Inzlicht, Schmeichel, & Macrae, 2014; Kurzban, Duckworth, Kable, & Myers, 2013). However, one psychological construct that has received little attention in the self-control strength literature is self-efficacy.

Self-efficacy refers to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Self-efficacy plays a critical role in effective self-regulation (cf. Bandura, 2012) as well as behavior change (Bandura, 1997), yet, self-efficacy is not recognized as a psychological factor that may affect or be affected by self-control strength. Indeed, Hagger et al.’s (2010) meta-analysis included only five effects (based on fewer than 200 observations) of self-control depletion on self-efficacy, which together yielded a non-significant effect size of d = .16. However, in studies of self-control strength depletion that have investigated self-efficacy, it is interesting to note that self-efficacy has been operationalized in ways that do not correspond with Bandura’s (1997) conceptual definition or recommendations for measurement (Bandura, 2006). For example, researchers have inferred self-efficacy from assessments of how participants felt they had performed on a previous self-control task or if they felt a reduced sense of general self-efficacy following self-control depletion (e.g., Englert & Bertrams, 2014a; Finkel, Dalton, Campbell, Brunell, Scarbeck, & Chartrand, 2006; Wallace & Baumeister, 2002). Because self-efficacy represents beliefs in one's abilities to perform specific tasks, neither self-evaluations of past performance or general feelings of ability should provide valid or sensitive indicators of self-efficacy for task performance. Thus, it is not surprising these studies concluded self-efficacy was not associated with self-control strength.

The purpose of the present study was to investigate the role of task self-efficacy as a psychological factor involved in the self-control depletion – physical performance relationship. Task self-efficacy refers to beliefs about one's capabilities to mobilize the resources required for successful performance of a specific task (Bandura, 1977). In the sport and exercise domain, task self-efficacy is a strong and reliable predictor of behavior, whereas general self-efficacy is not (Feltz & Chase, 1998; McAuley & Mihalko, 1998; Moritz, Feltz, Fahback, & Mack, 2000). One reason measures of general self-efficacy are poor predictors of behavior is that task demands vary considerably across behaviors and efficacy beliefs specific to those demands are not captured by generalized perceptions; certainly not self-efficacy for one's abilities to exert self-control to perform a specific task (Bandura, 1997; pp. 47-50). Furthermore, people benefit from prior experience with the behavioral demands of the tasks they are going to perform in order to accurately gauge their self-efficacy. In most studies of self-control strength, participants are asked to perform unfamiliar, laboratory-based, computer tasks for which they are unlikely to have a well-informed sense of task self-efficacy.

The lack of appropriate measurement is a methodological reason why self-efficacy may have failed to feature prominently as a factor in the self-control depletion literature. Another reason is that neither the strength model nor self-efficacy theory (Bandura, 1997) proposes a direct role for self-efficacy in the context of self-control strength depletion. However, we postulate that self-control strength depletion may have a negative effect on task self-efficacy for reasons accounted for by self-efficacy theory. According to self-efficacy theory, self-efficacy is influenced by prior task mastery, vicarious experiences, verbal persuasion, and physiological/affective states. According to Bandura (1997, pp. 106-107) fatigue is among the physiological/affective states that influence self-efficacy. The metaphorical resource governing self-control may represent a physiological or emotional state that influences self-efficacy to perform tasks involving self-control. Evidence (meta-analysis) aligning with this hypothesis is provided by Hagger et al. (2010), showing that subjective fatigue is greater following self-control depletion with an effect size of $d = 0.44$. Although subjective fatigue was not uniformly defined or measured in the studies reviewed by Hagger et al. (2010), it is clear that depleted participants experience an affective/physiological feeling state that could be described as fatigue. With these considerations in mind, we argue it is plausible that the diminished physiological resources or alterations in emotional states associated with self-control depletion may be sensed and interpreted such that self-efficacy to perform tasks dependent upon one's depleted resources will be negatively affected.

In the present study, participants were given prior experience with the dependent task to allow them to inform their task self-efficacy beliefs regarding task performance. They were also exposed to a manipulation of their self-control strength. In one condition, participants performed a task to deplete self-control strength, while in the other condition they performed a control task that would not deplete self-control strength. We hypothesized that self-control depletion would lead to poorer performance on the dependent task. Consistent with our argument above, we also expected that task self-efficacy would be negatively affected by self-control depletion. Given the strong and consistent relationship between self-efficacy and behavior (e.g., Bandura, 1997; Moritz et al., 2000), we further predicted that task self-efficacy would mediate the effect of self-control depletion on task performance.

Method

Participants and Design

Participants were 37 university students (20 women) with a mean age of 21.48 (*SD* = 2.93) years. The study utilized a single-blind, randomized experimental design with two levels of independent variable (depletion and no depletion) and two dependent measures: task self-efficacy and physical self-control task performance. In order to control for physical activity levels, recruitment criteria specified participants must have engaged in no more than 90 minutes of moderate-vigorous physical activity per week and no resistance training exercise during the previous six months.

Measures

Physical self-control. The change in physical self-control over two trials of a muscular endurance task served as the indicator of self-control performance and was represented by the difference in the amount of time (seconds) participants were able to sustain a 50% maximum voluntary contraction of an isometric handgrip squeeze across two endurance trials.

Prior to the first endurance trial, participants performed two, four-second 100% maximum voluntary contractions (separated by three minutes) using a handgrip dynamometer (model MLT003/D; ADInstruments, Colorado Springs, CO) with graphic computer interface (PowerLab 4/25T; ADInstruments, Colorado Springs, CO). The average force recording obtained from a one-second window at the peak of each maximum contraction was analyzed to determine peak force generation. The greatest peak force value was then used to determine the 50% maximum voluntary contraction target value for the endurance trials. The target force was shown as a static red line on a 17-inch computer monitor. In order to perform the endurance task, participants squeezed the handgrip dynamometer and were provided visual feedback on the computer monitor in the form of a force tracing (i.e., a real-time graphed line which indicated how much force was being generated). Participants were instructed to sustain a handgrip squeeze for as long as possible that kept their active force tracing line at, or slightly above, the static target line while resisting the temptation to quit. If the force tracing fell below the 50% maximum voluntary contraction criterion, participants were instructed to "squeeze harder so the line stays above the marker on the screen". The trial ended when the active force tracing line fell below the static line for longer than two seconds or when participants voluntarily stopped gripping the dynamometer.

The experimenter followed a script throughout the experimental sessions and no verbal encouragement or motivational feedback was provided at any time. Participants had no knowledge of elapsed time or the magnitude of force generation during the endurance trials. Physical self-control performance was represented by the number of seconds (time to failure) participants maintained an isometric handgrip squeeze at ≥ 50% of their maximum voluntary contraction for each trial performed. Time to failure was determined off-line, during data-analysis, using the Chart 5^{TM} graphing software application, which allowed for the identification of the start (when the force generation value initially met the 50% criterion) and end (the time at which the last break of the 50% force generation plane took place) of each endurance trial.

Task self-efficacy. Self-efficacy for task performance on the second endurance trial was assessed using an eight-item scale adhering to recommendations by Bandura (2006) for assessing self-efficacy. Each item was prefaced with the stem "*Compared to how long I went last time, I am confident* *that I can hold on for…"* The individual items represented hierarchical gradations of performance that were relative to the participant's performance on the previous trial. The scale began at *"25% as long (1/4 the amount)*" and increased by 25% at each interval up to *"200% as long (double the amount)*". Following guidelines provided by Bandura (2006), participants rated their confidence for each item using an 11-point, 0 (*not at all confident*) to 10 (*totally confident*), scale. The task self-efficacy score was computed by averaging the ratings for each interval score to produce a scale value out of 10. Internal consistency of the scale was Cronbach's $\alpha = .75$, which is considered acceptable (Nunnally & Bernstein, 1994) and comparable to those reported for hierarchical scales assessing self-efficacy in the sport and exercise area (Feltz & Chase, 1998).

Self-control Manipulation

Following the first endurance handgrip trial, participants completed either a modified incongruent Stroop color word task (self-control depletion) or a congruent color word task (control) for 5 minutes. For the modified incongruent Stroop color word task (Wallace & Baumeister, 2002), participants were presented with lists of words printed on laminated sheets of 8.5 x 14-inch paper (6 sheets with two 23-word columns on each sheet) in which the print ink color and printed text were mismatched (e.g., ink color was 'black' and the word text read 'green'). Participants were required to say aloud the color of the print ink and ignore the text for each word presented. In addition, when they encountered a word printed in red ink, they were required to override the general instructions and read aloud the printed word (e.g., ‘blue’) rather than saying the ink color (i.e., ‘red’). For the congruent (control) color word task, participants were presented with a list of words in which the print ink color and printed text were matched. The colors of the words were red, blue, green, black, yellow, orange, pink, and gray. If a participant completed all 6 sheets before the 5 minute period ended they started over on the first list and continued until the 5 minute period was over. The modified incongruent Stroop task has been used in numerous investigations as a manipulation to deplete self-control strength (e.g., Martin Ginis & Bray, 2010; Wallace & Baumeister, 2002) and has shown reliable, medium-sized, effects (Hagger et al., 2010).

Manipulation Checks

Ratings of perceived physical exertion. Following each endurance handgrip trial participants rated their perceived *physical* exertion using Borg’s CR-10 scale (Borg, 1998) in order to determine the extent to which they exerted their maximum effort on each trial.

Ratings of perceived mental exertion. To determine the effectiveness of the self-control depletion manipulation for requiring mental effort, participants rated their perceived *mental* exertion following the incongruent or congruent Stroop task using an adapted version of Borg’s (1998) CR-10 scale. Participants were asked to indicate how much *mental* effort was required to perform the Stroop task and rated their effort on the scale ranging from 0 (nothing at all) to 10 (absolute maximum). Numerous studies have used this scale when assessing perceived mental exertion (e.g., Bray, Graham, Martin Ginis, & Hicks, 2012).

Potential covariates

Trait self-control. The brief version of the Self-Control scale (Tangney, Baumeister, & Boone, 2004) assessed participants' general abilities to control thoughts, impulses, emotions, and maintain self-discipline. The brief Self-Control scale consists of 13 items rated on a 5-point Likert-type scale ranging from 1 (*not at all like me*) to 5 (*very much like me*). An example item is: *"I am good at resisting temptation"*. The measure demonstrated adequate internal consistency (α = .76).

Generalized self-efficacy. The New General Self-Efficacy scale (Chen, Gully, & Eden, 2001) was used to assess participants' perceptions of their general abilities across different tasks and situations. The scale consists of 8 items rated on a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). An example item is: "*I am confident I can perform effectively on many different tasks"*. Internal consistency for the scale was adequate (α = .82).

Motivation. Motivation for performing the endurance task was assessed using two measures. Immediately prior to each endurance trial, participants completed the single-item Task Motivation scale (Hutchinson, Sherman, Davis, Cawthon, Reeder, & Tenenbaum, 2011). The single-item Task Motivation scale is rated on an 11-point Likert-type scale ranging from 0 (*not at all motivated*) to 10 (*extremely motivated*). Participants read the following statement before completing the scale "*motivation refers to how much you want to keep going (persistence) and to the extent you want to push yourself to work harder (effort). How motivated are you to perform the upcoming task?*"

Participants also completed the 5-item effort and importance subscale from the Intrinsic Motivation Inventory (Ryan, 1982) prior to, and immediately following, each endurance trial. The effort and importance subscale is a 5-item 7-point Likert-type scale ranging from 1 (*not at all true*) to 7 (*very true*). For the pre-task measure each item was prefaced with the following stem "*For the handgrip task I am about to do*". An example item is: *"I am going to put a lot of effort into this*". For the post-task measure each item was prefaced with the following stem "*For the handgrip task I just completed*". An example item is: *"I tried very hard on that task"*. Internal consistency estimates for the pre-task and post-task scales were good (α's > .70). A trial-to-trial change score was computed to assess if motivation to perform the endurance trials differed between conditions across endurance trials.

Perceived effort and difficulty ratings. Two questions assessed participants' perceived effort and difficulty for the handgrip endurance task: (1) "*How much effort do you think the endurance handgrip task will require?*" and (2) "*How difficult do you think the endurance handgrip task will be?*" on an 11-point Likert-type scales ranging from 0 (*no effort*; *not difficult*) to 10 (*maximum effort*; *very difficult*). The same questions were used following each handgrip endurance task as well, except they were phrased in past tense (i.e., *"How much* *effort did the endurance handgrip task require?"* and *"How difficult was the endurance handgrip task?"*). The trial-to-trial change in pre-task and post-task perceived effort and difficulty scores were used to assess whether perceived effort or difficulty to perform the endurance trials differed between conditions across endurance trials.

Arousal. The Activation-Deactivation Adjective Check List-Short Form (Thayer, 1986) was used to measure arousal. The Activation-Deactivation Adjective Check List-Short Form consists of 20 adjectives for which participants rate their feelings, in the moment, on a 4-point Likert-type scale ranging from 0 (*definitely do not feel*) to 4 (*definitely feel*). The Activation-Deactivation Adjective Check List-Short Form consists of four subscales assessing general activation (energy), deactivation-sleep (tiredness), high activation (tension), and general deactivation (calmness). All subscales demonstrated adequate internal consistency (α's > .70).

Procedure

Prior to taking part in the study all of the participants self-identified for gender and were screened through email for habitual physical activity levels (i.e., < 90 minutes of moderate-vigorous physical activity per week and no resistance training for > six months) as well as any cardiac, orthopedic, respiratory or neurological problems that would inhibit them from performing an endurance isometric handgrip task or the modified Stroop task. Upon entering the lab, informed consent was obtained and the parameters of the study were explained.

Participants completed two 100% maximum voluntary handgrip squeezes separated by 3 min of rest. During the rest period participants completed demographic information, the brief Self-Control scale and the New General Self-Efficacy scale.

Following the second maximum voluntary contraction the experimenter setup up the feedback monitor with a static red line at the 50% maximum voluntary contraction criterion value and provided a 10-second demonstration of the task. Participants then performed a 10-second practice trial to familiarize themselves with the task.

There was a 5-minute rest period following the practice trial in which participants completed (in the following order): the pre-task perceived effort and difficulty measures, the pre-task Intrinsic Motivation Inventory effort and importance subscale, and the Task Motivation scale. Participants then completed the first endurance trial with the instructions to hold the contraction for as long as possible and *resist the temptation to quit*. After finishing the first endurance trial there was a 2-minute and 30-second interval period before the Stroop task. During this time participants were asked to provide a rating on the rating of perceived *physical* exertion scale and then completed the post-task perceived effort and difficulty measures and the post-task Intrinsic Motivation Inventory effort and importance subscale. They were then randomized (stratified by sex), using a random number generator (www.random.org), to either the depletion or control conditions.

Participants completed their respective experimental manipulation tasks (incongruent Stroop task or congruent Stroop task) after which they provided a rating of perceived *mental* exertion and completed the Activation-Deactivation Adjective Checklist-Short Form. There was then 5 minutes of rest in which all of the participants completed the task self-efficacy rating scale, the pre-task perceived effort and difficulty measures, the pre-task Intrinsic Motivation Inventory effort and importance subscale, and the Task Motivation scale. Participants then completed the second endurance trial with the instructions to hold the contraction for as long as possible and *resist the temptation to quit*. After finishing the trial the participants provided a rating on the rating of perceived *physical* exertion scale and completed the post-task perceived effort and difficulty measures and the post-task Intrinsic Motivation Inventory effort and importance subscale. Participants were debriefed and remunerated $15. The total time required to complete the study was approximately 40 minutes per participant. The study was approved by an Institutional Research Ethics Board.

Data Analysis

Descriptive statistics were computed for the study variables. Separate one-way analysis of variance (ANOVA) models were computed to assess differences in means between conditions for the potential covariates, which included: age, brief Self-Control scale, New General Self-Efficacy scale, the Intrinsic Motivation Inventory effort and importance subscale (pre and post task change scores), the perceived effort and difficulty measures (pre and post task change scores), and the Activation Deactivation-Adjective Checklist-Short Form subscales (energy, tiredness, tension, and calmness). The pre and post task Intrinsic Motivation Inventory effort and importance subscale, perceived effort, and difficulty change scores were calculated by subtracting pre-task scores for endurance Trial 1 from the pre-task scores for endurance Trial 2 and post-task scores for endurance Trial 1 from the post-task scores for endurance Trial 2.

Separate one-way analysis of variance (ANOVA) models were also computed to assess differences in means between conditions for the manipulation checks. The manipulation checks included: Stroop task performance (trials completed and errors made), ratings of perceived *physical* exertion, and ratings of perceived *mental* exertion.

Between-group differences in the dependent variables (time to failure change and task self-efficacy) were also assessed using one-way ANOVAs. Residualized change scores for time to failure were also analyzed. Residualized change scores have been used in addition to raw change scores to determine physical endurance performance effects of self-control depletion (e.g., Bray et al., 2008; Graham et al., 2014) and were calculated by regressing the Trial 2 contraction duration on the Trial 1 contraction duration (Cohen, Cohen, Aiken, & West, 2003). Residualized change scores are used because they control for the negative correlation between baseline scores and raw change scores, as individuals who hold longer muscular contractions tend to have larger trial-to-trial changes.

Bivariate (Pearson's *r*) correlation coefficients were computed for the relationships between condition, raw time to failure change score, residualized time to failure change score, and task self-efficacy. Tests for indirect (mediation) effects were assessed using the *PROCESS* software macro (Hayes, 2013). All statistical analyses were conducted using SPSS version 20.

Results

Demographics and Potential Covariates

Descriptive statistics for demographics and potential covariates are shown, by group, in Table 1. Analyses revealed no significant differences between conditions on participants' age, *F* (1, 35) = 0.09, *p* = .76, *d* = 0.10, the brief Self-Control scale, *F* (1, 35) = 2.99, *p* = .10, *d* = 0.56, the New General Self-Efficacy, *F* (1, 35) = 1.48, *p* = .23, *d* = 0.39, the change in Intrinsic Motivation Inventory effort and importance subscales for the pre-trial scores, *F* (1, 35) = .37, *p* = .55, *d* = 0.19 and post-trial scores, *F* (1, 35) = .01, *p* = .92, *d* = 0.04, the change in perceived effort for the pre-trial, *F* (1, 35) = 2.71, *p* = .11, *d* = 0.54 and post-trial scores, *F* (1, 35) = 0.17, *p* = 68, *d* = 0.16, and the change in perceived difficulty pre-trial, *F* (1, 35) = 0.65, *p* = .43, *d* = 0.27 and post-trial scores, *F* (1, 35) = 0.22, *p* = .64, *d* = 0.15. Results also revealed no differences between groups on the four Activation Deactivation-Adjective Checklist-Short Form subscales: energy; *F* (1, 35) = 0.05, *p* = .83, *d* = 0.07, tiredness; *F* (1, 35) = 0.00, *p* = .99, *d* = 0.003, tension; *F* (1, 35) = 0.10, *p* = .75, *d* = 0.11, and calmness; *F* (1, 35) = .94, *p* = .34, *d* = 0.32.

There was a significant difference between conditions for the change in scores for the Task Motivation scale from Trial 1 to Trial 2, *F* (1, 35) = 6.91, *p* = .01, *d* = 0.86. However, it is critical to note the difference was a shift in motivation showing lower motivation in the control group compared to the depletion group prior to Trial 2, which is in the opposite direction to that predicted by motivational theories of self-control depletion (e.g., Inzlicht et al., 2014). Although Task Motivation was significantly associated with the experimental manipulation, it was not significantly correlated with either self-efficacy (*r* = -.01, *p* > .10) or change in handgrip endurance (*r* = -.14, *p* > .10); therefore it was not used as a covariate in the main analyses.

Manipulation Checks

Descriptive statistics summarizing the manipulation check measures for the sample are shown, by group, in Table 1. A series of one-way ANOVAs were computed on the manipulation check measures. Consistent with the intent of the self-control depletion manipulation, participants in the depletion condition reported significantly greater ratings of perceived *mental* exertion following the Stroop task compared to controls (*F* (1, 35) = 29.90, *p* < .001, *d* = 1.80). They also completed significantly fewer trials (one word every 1.25s vs. one word every 0.60s: *F* (1, 35) = 97.30, *p* < .001, *d* = 3.22) and made more errors than controls (8.79 and 0.44, respectively: *F* (1, 35) = 105.47, *p* < .001, *d* = 3.42), which is consistent with the greater inhibition and processing demands of the incongruent Stroop task (MacLeod, 1991). Ratings of perceived exertion for the handgrip task did not differ between the groups for either Trial 1 *F* (1, 35) = .03, *p* = .88, *d* = 0.05, or Trial 2, *F* (1, 35) = .38, *p* = .54, *d* = .20, showing both groups perceived exerting maximum effort.

Main Analyses

Physical self-control task performance was evaluated using separate analyses for the raw and residualized change scores (time to failure) from Trial 1 to Trial 2. Descriptive statistics summarizing the Trial 1 to Trial 2 raw and residualized endurance handgrip scores are presented in Table 2. As seen in Table 2, there was a 14 second reduction in time to failure in the depletion group compared to a 1.5 second reduction in the control group. A one-way ANOVA revealed significant differences between conditions for both raw, *F* (1, 35) = 5.93, *p* = .02, *d* = 0.80, and residualized change scores, *F* (1, 35) = 7.14, *p* = .01, *d* = 0.88.

Descriptive statistics summarizing the task self-efficacy scores are also presented in Table 2. The depletion group reported lower self-efficacy for the second trial (relative to their performance on the first endurance trial) compared to controls (Means = 3.01 and 4.05, respectively). A one-way ANOVA revealed that the difference between these scores was significant (*F* (1, 35) = 13.82, *p* = .001, *d* = 1.22).

Indirect (Mediation) Effects

To evaluate our hypothesis that task self-efficacy mediates the effect of self-control depletion on handgrip performance (raw time to failure change and residualized change), indirect effects analyses were computed. Preliminary examination of the correlation coefficients (Pearson's *r*) between experimental conditions, time to failure change, and task self-efficacy showed significant ($p < .05$) bivariate relationships between all of the variables with *r*(37)'s ranging from 0.38-0.84 (See Table 3).

In the first mediation analysis, time to failure change was specified as the dependent variable with experimental condition (depletion/ control) specified as the independent variable and task self-efficacy as the mediator. As recommended by Hayes and Scharkow (2013), bias-corrected bootstrap procedures utilizing 10,000 simulations were computed. Kappa-squared ($_k{}^2$) values (Preacher & Kelly, 2011), which represent the proportion of the maximum possible indirect effect that was accounted for by the mediator (task self-efficacy) in the model, was also computed to provide an effect size estimate. Results of the regression analyses performed using *PROCESS* (Hayes, 2013) showed there was a significant direct effect of condition on handgrip endurance change, 95% C.I. = 2.09-23.02, $p = .02$, a significant direct effect of condition on self-efficacy, 95% C.I. = 0.47-1.60, $p = .0007$, and a significant direct effect of self-efficacy on performance (controlling for condition), 95% C.I. = 4.08-15.11, $p = .001$. Results of the *PROCESS* analyses indicated a significant indirect (mediation) effect for task self-efficacy on the condition--time to failure change relationship (95% C.I. = 3.78-20.03, $_k{}^2 = 0.29$) indicating 29% of the maximum possible indirect effect was accounted for by self-efficacy. The relationship between condition and time to failure change was reduced from $R^2 = .15$ to $R^2 = .005$ after controlling for the effect of task self-efficacy.

A second mediation analysis was carried out using the residualized change scores. Overall, the results were virtually identical to those produced by the raw change scores with a significant indirect (mediation) effect for task self-efficacy (95% C.I. = 2.82-18.08, $_k{}^2 = 0.30$).

Discussion

The present study investigated the effects of self-control depletion on task self-efficacy and physical self-control performance. It was hypothesized that following self-control depletion, task self-efficacy and physical self-control endurance performance would be negatively affected. Furthermore, given the strong and consistent relationship between self-efficacy and behavior (Bandura, 1997; Moritz et al., 2000), it was also hypothesized that task self-efficacy would mediate the effect of self-control depletion on performance. Consistent with our hypotheses, task self-efficacy and physical self-control performance were reduced following self-control depletion and task self-efficacy partially mediated the effect of self-control depletion on endurance performance.

As previously discussed, self-efficacy has been operationalized in a variety of ways when it has been investigated in the self-control strength literature. In one study, Wallace and Baumeister (2002) inferred a decrease in self-efficacy through a manipulation check based on bogus feedback. However, they assessed participants' beliefs about their performance on a previous task rather than an evaluation of what they believed they could do on the dependent task. Further attempts to assess self-efficacy's role within the self-control depletion-performance relationship utilized similar measures (e.g., Englert & Bertrams, 2014a) or other approaches assessing generalized self-efficacy (e.g., Finkel et al., 2006) rather than beliefs about abilities to perform tasks that demand self-control strength. In short, the treatment of self-efficacy as a construct in prior research on self-control strength depletion was not consistent with how the concept is represented within self-efficacy theory (Bandura, 1997), which clearly defines self-efficacy as beliefs regarding task competencies. Given task self-efficacy was not adequately assessed, the role of self-efficacy may not have been fully evaluated in prior research.

As far as we are aware this is the first time task self-efficacy has been assessed in a study involving the sequential task paradigm used in self-control strength depletion research. Our finding that task self-efficacy is reduced following self-control depletion has implications both for the strength model and self-efficacy theory. Specifically, after participants were depleted of their self-control strength, they reported lower self-efficacy to perform a second handgrip endurance trial compared to participants in the control group. According to self-efficacy theory, past performance mastery is the most powerful source of self-efficacy. Yet, this finding emerged despite both groups performing identically on the first test of handgrip endurance. Given equal mastery of the handgrip task, we can infer that self-control strength depletion brought on by the Stroop task caused self-efficacy to decline as a result of some other determinant of self-efficacy. Because verbal persuasion was controlled and vicarious experiences were not manipulated, the most likely factors leading to reduced self-efficacy are emotional or physiological experiences that occurred during or shortly after the Stroop task.

Multiple prior studies have tested for variations in mood or emotion following self-control depletion and found no effects, or very small negative effects, associated with those manipulations (cf. Hagger et al., 2010). Therefore, although there were no measurements of emotional states following the self-control depletion manipulation in the present study, it is unlikely that emotional states would account for the reductions in self-efficacy we observed. In place of typical mood or emotional state measures, we focused on potential variations in perceived arousal that might be brought on by the self-control strength manipulation. However, a comparison of scores across the four Activation Deactivation-Adjective Checklist subscales revealed no differences between the groups. Thus, there appears to be no difference in perceived arousal that can account for reduced self-efficacy in the self-control depletion group either[1]. Based on these findings, we recommend future research not only continue investigation of self-efficacy as a factor that is affected by self-control depletion, but also explore additional measures to those currently used to assess emotional and physiological consequences of self-control depletion.

According to Muraven and Baumeister (2000; see also Baumeister et al., 2007), self-control strength depletion is something that cannot be observed directly, but must be inferred from people's behavior. However, there is some evidence that one's state of self-control depletion may be consciously perceived. For instance, recent attempts to quantitatively assess self-control depletion using subjective ratings have been reported to have validity and reliability (Ciarocco, Twenge, Muraven, & Tice, 2004). The obvious question arising from these research endeavors is "what does self-control depletion feel like?" Our understanding of self-control strength, factors that deplete it, and how it can be effectively managed would benefit from a valid and reliable operational definition of the resource construct. We suggest the "feeling" of depletion, whether emotional or physiological, may be similar to a subjective feeling state akin to fatigue and may be an influential factor determining one's self-efficacy to perform tasks that demand self-control.

The negative effect of self-control depletion on self-efficacy observed in the present study is an important discovery that can aid in the interpretation of prior research findings and inform a more considerate view of self-control depletion. Several studies have investigated moderating variables and shown that the negative effects of self-control depletion can be overcome under certain circumstances (for a review see Masicampo, Martin, & Anderson, 2014). For example, enhancing positive affect prior to performing a task requiring self-control attenuates the negative effects of self-control depletion (e.g., Egan et al., 2015; Tice et al., 2007). According to Bandura (1997) positive affect enhances self-efficacy; therefore, increased self-efficacy provides a theory-based psychological mechanism that can account for better self-control performance. Also, recent studies have shown that vicarious experiences (e.g., Ackerman, Goldstein, Shapiro, & Bargh, 2009; Englert & Bertrams, 2014b) and imagined experiences (e.g., Graham et al., 2014; Macrae et al., 2014) can lead to self-control depletion. In these studies, no direct manipulations of self-control strength were carried out; therefore, it stands to reason that the observed deterioration in self-control is attributable to intermediary or parallel mechanisms that compromise task performance. Vicarious or imagined tasks may not directly deplete self-control strength; however, they would have predictable effects on task self-efficacy (cf. Bandura, 1997). In these instances, self-efficacy provides a reasonable, theory-based, explanation for findings that are not readily accounted for by the strength model.

Self-efficacy may also be an important consideration for basic and applied research investigating ways in which self-control may be enhanced or trained. For example, studies have shown that systematically performing tasks that require self-control such as using one's non-dominant hand to perform daily tasks (Gailliot, Plant, Butz, & Baumeister, 2007) or practicing squeezing a handgrip exerciser (Bray et al., 2015) can lead to increases in self-control strength (for reviews see Baumeister, Gailliot, DeWall, & Oaten, 2006 and Friese, Hofmann, & Wiers, 2011). In these training studies, where self-control strength was hypothetically enhanced, it is critical to note that the self-control training tasks were different from the dependent measures of self-control. Thus, it is possible that repeated exposure to tasks requiring self-control increased one's mastery at exerting self-control, which may have also increased one's self-efficacy to exert self-control. The idea that self-efficacy can generalize across tasks requiring common capacities (i.e., self-control) is consistent with self-efficacy theory (Bandura, 1997, p. 51).

Another important contribution of the present study is our examination of self-efficacy as mediating mechanism within the self-control strength depletion – task performance relationship. To this point in time, several physiological and neurological mechanisms underlying the self-control strength depletion have been proposed and investigated (Beedie & Lane, 2012; Brass et al., 2013), however there have been few attempts to assess psychological mediators. Recently, several theorists (e.g., Inzlicht et al., 2014; Kurzban et al., 2013) have proposed self-control strength depletion may evoke a rational cost-benefit analysis or a de-motivating process that may lead to withdrawal of effort or resources allocated to self-control. Contrary to these views, our results did not show any reductions in task motivation following depletion. However, the results are consistent with this theorizing, as well as self-efficacy theory, insofar as self-efficacy is a motivational perception that guides behavior (Bandura, 1997) and appears to be reduced following self-control depletion.

Although self-efficacy was found to partially mediate the self-control strength depletion effect on handgrip endurance, it is important to acknowledge that self-efficacy accounted for approximately 30% (i.e., ${}_{k}^{2} = 0.29$) of the total mediated effect. Thus, several other factors are likely to play a meditational role in this relationship. As previously mentioned, neuroscientific evidence (e.g., Wagner & Heatherton, 2013) indicates that self-control depletion is associated with cerebral activation patterns in the anterior cingulate cortex, basal ganglia, lateral prefrontal cortex, ventromedial prefrontal cortex, and amygdala. Furthermore, research has shown that following self-control depletion, via cognitive task performance, neuromuscular perturbations are seen that are reflective of muscle fatigue (Bray et al., 2008; Graham et al., 2014; Pageaux, Marcora, Rozand, & Lepes, 2015). These neurological and muscular effects may represent mediating processes occurring at biological levels that could account for complementary or overlapping variance in task performance.

Limitations and Future Directions

The present study shows that task self-efficacy is negatively affected by self-control strength depletion and partially mediates the effect of depletion on performance of a muscular endurance task. However, there are a number of limitations that should be noted. For instance, the participants in our study were relatively inactive (<90 minutes of moderate-vigorous physical activity per week). Therefore, results may not be generalizable to those who are more active, such as competitive or trained sport performers. Research has shown that competitive rowers, rugby players, and hockey players experience negative effects of self-control depletion (Dorris et al., 2012). Nevertheless, future research should investigate if self-control strength depletion has similar effects on task self-efficacy among active or trained sport participants.

Another limitation is that the endurance handgrip task was a novel task and participants had limited experience upon which to base their self-efficacy ratings. Although both groups were exposed to the same level of task mastery on the handgrip task in this study (i.e., performed one trial and achieved nearly identical performance scores), future research should assess whether changes in self-efficacy occur for tasks that are well-known or practiced. Given that several studies have shown self-control strength depletion effects in sport and exercise (e.g., Englert & Bertrams, 2014a; Wagstaff, 2014) and that self-efficacy has been shown to correlate positively with sport performance (Moritz et al., 2000), changes in self-efficacy following self-control depletion should be explored further as a potential mediator of the effects of self-control strength depletion on performance for ecologically-valid sport tasks.

In sum, the present study provides evidence that task self-efficacy is negatively affected following self-control depletion. Furthermore, we found that task self-efficacy mediates the relationship between self-control depletion and performance. These results suggest that task self-efficacy is a potent psychological construct that should be investigated more thoroughly as a factor accounting for changes in endurance exercise performance following self-control strength depletion.

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Footnotes

[1] Supplemental analyses computed using *PROCESS* showed that none of the indirect effects of the four AD-ACL subscales on the association between the experimental condition and task self-efficacy were significant ($p > .05$).

Table 1

Comparison of Age, Potential Covariates, and Manipulation Checks by Condition

	Depletion *n* = 19 *M* (*SD*)	Control *n* = 18 *M* (*SD*)	*p*	*d*
Age	21.63 (2.77)	21.33 (3.16)	.76	0.10
Potential covariates				
Brief Self-Control scale	45.60 (6.93)	41.90 (6.36)	.10	0.56
New General Self-Efficacy scale	4.00 (0.41)	3.82 (0.51)	.23	0.39
AD-ACL energy	12.03 (3.38)	12.28 (3.56)	.83	0.07
AD-ACL tiredness	11.18 (3.83)	11.17 (3.55)	.99	.003
AD-ACL tension	8.79 (2.42)	8.50 (3.07)	.75	0.11
AD-ACL calmness	12.47 (2.55)	11.61 (2.87)	.34	0.32
Task Motivation Δ	0.26 (0.99)	-0.78 (1.40)	.01	0.86
IMI pre-task Δ	0.28 (0.46)	0.16 (0.79)	.55	0.19
IMI post-task Δ	0.07 (0.44)	0.09 (0.48)	.80	0.04
Perceived effort pre-task Δ	0.95 (1.08)	0.39 (0.98)	.11	0.54
Perceived effort post-task Δ	0.21 (0.79)	0.11 (0.68)	.68	0.16
Perceived difficulty pre-task Δ	1.16 (1.74)	0.72 (1.53)	.43	0.27
Perceived difficulty post-task Δ	0.42 (1.30)	0.61 (1.15)	.64	0.15
Manipulation Checks				
RPME	6.84 (2.08)	2.83 (2.36)	<.001	1.80
Stroop trials completed	251.11 (55.24)	526.83 (106.88)	<.001	3.22
Stroop errors	8.79 (3.29)	0.44 (1.04)	<.001	3.42
Trial 1 RPE	8.68 (1.56)	8.61 (1.10)	.88	0.05
Trial 2 RPE	9.08 (0.92)	8.89 (0.96)	.54	0.20

Note: d = Cohen's *d* (effect size), IMI = Intrinsic Motivation Inventory (effort and importance subscale), AD-ACL = Activation-Deactivation Adjective Check List-Short Form, Δ = trial-to-trial change, RPE = Ratings of Perceived Physical Exertion, RPME = Ratings of Perceived Mental Exertion.

Table 2

Handgrip Endurance, Trial-to-Trial Change Scores, and Self-Efficacy scores by Condition

	Depletion *n* = 19 *M* (*SD*)	Control *n* = 18 *M* (*SD*)	*p*	*d*
Trial 1 handgrip score (s)	79.42 (26.27)	76.22 (33.05)	.75	0.11
Trial 2 handgrip score (s)	65.37 (24.65)	74.72 (25.52)	.26	0.37
Trial 1 – Trial 2 Δ (s)	-14.05 (15.44)	-1.50 (15.92)	.02	0.80
Trial 1 – Trial 2 residualized Δ	-5.65 (14.27)	5.96 (14.98)	.01	0.88
Task self-efficacy	3.01 (0.78)	4.05 (0.91)	.001	1.22

Note: *d* = Cohen’s *d* (effect size), s = seconds. Δ = trial-to-trial change.

Table 3

Bivariate Correlations (Pearson's r) between Experimental Condition, Handgrip Endurance Trial-to-trial Change Scores, and Task Self-efficacy

	1	2	3
1. Condition (0 = control, 1 = depletion)			
2. Trial 1 – Trial 2 Δ (s)	-.38*		
3. Trial 1 – Trial 2 Residualized Δ	-.41*	.86**	
4. Task self-efficacy	-.53**	.68**	.64**

Note: * = *p* < .05, ** = *p* < .01, s = seconds. Δ = trial-to-trial change.

CHAPTER 3

Self-Control Strength Depletion Reduces State Self-Control Capacity, Task Self-Efficacy, and Impairs Resistance Exercise Performance

Preamble

Self-Control Strength Depletion Reduces State Self-Control Capacity, Task Self-Efficacy, and Impairs Resistance Exercise Performance is the second study in the dissertation series. This study investigates the effect of self-control strength depletion on resistance exercise performance (seated bench press and leg extension). This study also investigates the effect of self-control strength depletion on subjective fatigue (assessed through the self-control capacity scale (SSCCS)). Finally, this study tested a sequential mediation model predicting self-control depletion → reduced SSCCS → reduced task self-efficacy → reduced task performance.

The manuscript is not currently submitted for publication in a journal and has been formatted for this dissertation.

Contribution of Study 2 to overall dissertation

Study 2 builds upon Study 1 by providing the first evidence that self-control depletion leads to reductions in self-control performance through a sequentially-mediated process involving subjective fatigue and self-efficacy. However, it remains unclear to what extent that self-efficacy plays a passive or active role guiding self-controlled behaviour following self-control depletion.

Abstract

The purpose of this study was to investigate sequential indirect pathways by which self-control depletion affects resistance exercise performance through subjective (self-control) fatigue and task self-efficacy. Participants (*N* = 50) completed two sets of maximum repetitions at submaximal loads on bench press and leg extension resistance exercises separated by a Stroop task, which was either congruent (control) or incongruent (causing depletion). State self-control capacity (self-control fatigue) and task self-efficacy were assessed following the Stroop task. Participants in the depletion condition reported lower state self-control capacity, task self-efficacy, and showed a greater reduction in resistance exercise performance compared to controls. Results also support the proposed serial mediation model suggesting that exertion of self-control causes increased subjective fatigue, which in turn, leads to reduced self-efficacy to exert further self-control and subsequent reductions in self-controlled task performance.

Self-Control Strength Depletion Reduces State Self-Control Capacity, Task Self-Efficacy, and Impairs Resistance Exercise Performance

Self-regulation or self-control refers to the process of exerting control over one's thoughts, emotions, or behaviors in order to attain a desired standard (Carver & Scheier, 1998; Baumeister, 2014). Self-control is related to many positive behavioral and health outcomes such as success in school and work settings and sport and exercise performance (Bray, Martin Ginis, Hicks, & Woodgate, 2008; de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). However, exerting self-control is an effortful process that leaves people susceptible to self-control failures (Baumeister & Heatherton, 1996).

Evidence based on the strength model of self-control (Baumeister, Vohs, & Tice, 2007; Baumeister, 2014) shows when people exert self-control over their thoughts, emotions, or behaviors for a period of time, subsequent acts that require self-control are negatively affected (for a meta-analysis see Hagger, Wood, Stiff, & Chatzisarantis, 2010). Baumeister and colleagues have termed the psychophysiological state induced by self-control exertion "ego-depletion". Although there is an ongoing debate regarding what (if anything) is actually depleted (Baumeister, 2014; Beedie & Lane, 2012; Inzlicht & Schmeichel, 2015; Kurzban, Duckworth, Kable, & Myers, 2013), one intermediary factor that has emerged in the mechanistic flow of performance from one self-control task to the next is an increase in ratings of subjective fatigue following the "depleting" task (d = 0.44, Hagger et al., 2010). That is, following the execution of "depleting" tasks, participants have rated their fatigue at higher levels than those who completed control tasks. Given these ratings occur following depletion and prior to the criterion task, it is clear that the depleting task imparts a different psychophysiological sensation of fatigue than the control task. We believe this evidence suggests subjective fatigue may play an important role that may directly or indirectly influence subsequent attempts to exert self-control.

Although it is evident that subjective fatigue states are higher following depletion, it is interesting to note that the majority of the studies (*k* = 26) reviewed in Hagger et al.'s meta-analysis (2010) assessed subjective fatigue haphazardly; typically using single-item measures developed by the study authors (e.g., Baumeister, Bratslavsky, Muraven & Tice, 1998, Studies 1 and 4; Friese, Hofmann, & Wanke, 2008; Studies 2 and 3; Muraven, Tice, & Baumeister, 1998; Study 1). However, a notable exception to this practice is the use of a measure called the State Self-Control Capacity Scale (SSCCS) developed by Ciarocco, Twenge, Muraven and Tice (2004). This 25-item measure is based on the conceptual notion that people sense their level of self-control capacity at any given time and, in particular, they can feel when their self-control resources are fatigued. The SSCCS operationalizes subjective (self-control) fatigue using a collection of items that correspond with various descriptive forms of fatigue states. For example, items include "*I feel drained*", *"I feel mentally exhausted", "I feel worn out", "I want to give up", "My mental energy is running low", and "I wish I could just relax for a while"*.

The original studies relating to the development of the SSCCS are not published; however Ciarocco et al. (2004) report findings that support its reliability and construct validity. For example, the SSCCS showed high internal consistency across 5 studies (Cronbach's $\alpha = 0.90 - 0.95$). Studies 3 and 4 supported the SCCSS's construct validity with participants consistently reporting lower scores on the SSCCS following exposure to self-control depletion manipulations. Additional evidence supporting the SSCCS's validity comes from several studies that have applied the measure as a manipulation check following self-control depletion manipulations (e.g., Smolders & De Kort, 2014) and as baseline (covariate) measure of state self-control capacity (e.g., Bertrams, Englert, & Dickauser, 2010). A recent study also found the SSCCS is strongly correlated with other measures assessing subjective fatigue states (Salmon, Adriaanse, De Vet, Fennis, & de Ridder, 2014). For instance, when assessed concurrently, participants' scores on the Depletion Sensitivity Scale (Studies 2 and 3) and the Multidimensional Fatigue Inventory (Study 2) (Smets, Garssen, Bonke, & Haes, 1995), which measures five dimensions of fatigue, were moderately to highly correlated with the SSCCS (*r*s 0.45-0.61). Together, these findings suggest that self-control strength depletion results in a psychophysiological sensation of subjective fatigue that is consciously perceived and can be measured using the SSCCS. Thus, a critical question arises as to the extent to which subjective fatigue can indirectly account for (i.e., mediate) the effect of prior self-control exertion on future self-control performance.

There are at least two pathways through which subjective fatigue could mediate the effect of prior self-control strength depletion on subsequent self-control: as a single mediator or as part of a sequential mediation process involving additional variables. One way in which subjective fatigue could affect self-control performance as part of a sequential mediation process is via its effects on self-efficacy. Recent research based on the strength/energy model of self-control has shown that task self-efficacy is lower following self-control exertion and partially accounts for the negative change that occurs in subsequent self-control performance (Chow, Hui, & Lau, 2015; Graham & Bray, in press).

Chow et al. (2015) showed that people consistently rate their task self-efficacy lower after they complete tasks that are designed to deplete self-control (*d*'s ranging from 0.48-0.61). They also discovered that changes in self-efficacy partially mediated the effect of the self-control depletion manipulation on cognitive self-control performance (Studies 2 and 3). In the study by Graham and Bray (in press), participants performing maximum physical endurance tasks reported lower task self-efficacy after completing a self-control depletion manipulation compared to a non-depleting control task ($d = 1.22$). Task self-efficacy was also found to partially mediate the negative performance change (time to failure) observed when participants performed the subsequent handgrip endurance trial. Based on these findings, self-efficacy appears to play an important role in the self-control depletion – performance relationship. However, given these results are derived from only two studies and based on either cognitive performance or simple muscular endurance tasks, further research is needed to fully assess the effects of task self-efficacy in the self-control of behavior across a range of emotional, cognitive, and physical self-control tasks.

Although it is apparent that self-efficacy plays an important role in the self-control depletion – performance relationship, a pertinent theoretical consideration relates to why self-efficacy decreases following depletion. Going back to self-efficacy theory (Bandura, 1997), self-efficacy beliefs are influenced by four main sources: past performance mastery, vicarious experiences, verbal persuasion, and physiological/affective states. According to Bandura (1997, p. 106), changes in subjective fatigue are among the physiological/affective states that influence self-efficacy; such that increased fatigue decreases self-efficacy. Thus, a putative process is as follows: exerting self-control on a task leads to increased subjective fatigue, which in turn, leads to reduced self-efficacy to exert further self-control and reductions in performance on subsequent self-control tasks.

The overarching objective of the present study was to test a serial mediation model examining the sequential indirect pathways in which self-control depletion affects resistance exercise performance through subjective fatigue and self-efficacy. The present study took place over two lab visits separated by 72 hours. During an initial baseline testing session, participants' *predicted* one repetition maximum (1RM) was determined on two resistance exercise machines (seated bench press and leg extension). In a subsequent experimental testing session, participants completed two sets of resistance exercises on bench press (@ 60% of 1RM) and leg extension (@ 40% of 1RM) to exhaustion. In between the two sets, they were exposed to a self-control strength manipulation. In one condition, participants performed a task (incongruent Stroop task) characteristically shown to deplete self-control strength, while in the other condition they performed a control task (congruent Stroop task) that does not deplete self-control strength. Consistent with the findings reviewed above, we hypothesized that self-control depletion would lead to lower scores on the SSCCS, lower task self-efficacy, and a reduction in physical self-control endurance performance (fewer repetitions completed on bench press and leg extension) compared to controls. We further hypothesized that state self-control capacity and task self-efficacy would sequentially mediate (serial mediation) the effect of self-control depletion on task performance. Specifically, we first hypothesized that self-control depletion would have an indirect effect on task self-efficacy through state self-control capacity (depicted in Figure 1a) and second, that state self-control capacity and task self-efficacy would have sequential indirect effects accounting for the relationship between the self-control strength manipulation (control/depletion) and later self-control performance (number of repetitions of resistance exercise performed) (depicted in Figure 1b).

Method

Participants and Design

Participants were 50 recreationally-active university students (*n* = 29 women) with a mean age of 20.98 (*SD* = 2.83) years. Inclusion criteria required participants to have engaged in less than public health recommendations for physical activity (<150 min of moderate-vigorous physical activity per week (MVPA)) (Tremblay et al., 2011), which was verified by administering the Godin Leisure Exercise Time Questionnaire (Godin & Shephard, 1985) during the first visit to the lab. As well, participants were required to have had previous experience performing resistance exercise but not engaged in resistance exercise training currently or within the previous six months. Participants also underwent initial screening for medical contra-indicators for strenuous physical activity using the physical activity readiness questionnaire (PAR-Q; Thomas, Reading, & Shephard, 1992).

The study utilized a single-blind, randomized experimental design with two levels of independent variable (depletion/no depletion) and three dependent measures: state self-control capacity, task self-efficacy, and physical self-control task performance. The primary hypotheses related to a one-way ANOVA for which a sample-size calculation (G*Power version 3.1.9.2; Faul, Erdfelder, Buchner, & Lang, 2009), based on large effect sizes, power = .80, and $\alpha = 0.05$, indicated a sample of *N* = 32 was sufficient for the analysis. The hypotheses relating to the single and serial meditation models for which a sample-size calculation (G*Power version 3.1.9.2; Faul et al., 2009), based on large effect sizes, power = .80, and α = 0.05, indicated a sample of *N* = 31 was sufficient for the single mediation analyses and a sample of *N* = 36 was sufficient for the serial mediation analyses. The anticipation of a large effect sizes was based on previous research involving the SSCCS (Ciarocco et al., 2004, Study 3) and the effects of self-control depletion on task self-efficacy and physical self-control (Graham & Bray, in press).

Measures

Physical self-control. Physical self-control was assessed using two forms of resistance exercise; each of which were performed to exhaustion. Seated bench press was performed at 60% of 1RM (predicted) and leg extension at 40% of 1RM (predicted). Participants' *predicted* 1RM was calculated prior to the experimental testing session using a standard method and formula (http://www.exrx.net/Calculators/OneRep Max.html) which required participants to perform 10 repetitions of the exercise using progressively heavier weight until they reached a resistance at which they could no longer perform 10 repetitions in a continuous set. Initially, participants completed 10 repetitions at a relatively light weight (females = 30lbs (pounds) and males 60lbs) on both the bench press and leg extension. Following each set the experimenter asked the participant to provide a rating of perceived *physical* exertion (Borg, 1998) for the set they just completed. If the rating was low (i.e., 0-2) the weight was doubled, if the rating was moderate-strong (3-6) 15lbs was added for females and 25lbs for males, and if the rating was high (7+) 10lbs was added for females and 15lbs for males. There was three minutes of rest between each set. The procedure required performance of 3-4 sets on each exercise.

Participants returned to the lab for the experimental session 72 hours later. To ensure participants were unaware of how many repetitions they completed during the testing, a computer monitor was placed in front of the participants prior to completing the exercises which presented random single digit numbers (every two seconds). The participant was instructed to complete a repetition each time a number appeared and to say out loud that number. Participants were told that near the end of each exercise if they are unable to maintain pace with the numbers to keep going ignoring the pace but saying the number out loud that was visible on the screen when they finished each repetition. Participants were told that in order to complete the task correctly they should perform the task continuously with each repetition immediately following the one preceding while maintaining pace with the numbers, were not allowed to rest at any point, and were to *resist the temptation to quit*. In a pilot study, using this procedure, participants were asked to estimate how many repetitions they believed they had performed at the completion of each set. Based on data from 27 participants, the correlation between the actual and estimated number of repetitions performed was $r = .39$, $p = .052$. Participants generally underestimated the number of repetitions performed on both bench press ($M = -9.26$) and leg extension ($M = -5.24$). Thus, the number repetition task did not allow participants to accurately monitor their task performance.

For the experimental session, participants completed an initial set of repetitions on bench press to failure, rested for one minute, and then a set of repetitions on leg extension to failure. Participants had ~13 minutes of no-exercise rest prior to completing the second set of repetitions to failure on bench press, followed again by one-minute of rest, and a set of repetitions until failure on leg extension. The experimenter followed a script throughout the experimental session and no motivational feedback or verbal encouragement was provided at any time. For each set of exercises, a male lab assistant and the experimenter recorded the number of repetitions completed during each set. The change in the number of repetitions performed from the first to the second set of each exercise (i.e., # of second set repetitions - # of first set repetitions) served as independent indicators of self-control performance.

State self-control capacity. The brief version of the State Self-Control Capacity Scale (SSCCS; Ciarocco et al., 2004) was used to assess participants' perceptions of their self-control capacity (i.e., subjective fatigue) following the Stroop task. The scale consists of 10 items rated on a 7-point Likert-type scale ranging from 1 (*not true*) to 5 (v*ery true*). An example item is: "*I feel like my will power is gone".* Internal consistency for the scale was good ($\alpha = .85$).

Task self-efficacy. Self-efficacy for task performance on the second set of exercises was assessed using two eight-item 11-point, 0 (*not at all confident*) to

10 (*totally confident*), scales (one for each exercise). Adhering to recommendations by Bandura (2006) for assessing self-efficacy, each item was prefaced with the stem "*Compared to how many repetitions I completed last time on <u>bench press/leg extension</u>, I am confident I can complete:"* The individual items represented hierarchical gradations of performance that were relative to the participant's performance on the first sets. The scale began at *"25% as many repetitions (1/4 the amount)*" and increased by 25% at each interval up to *"200% as many repetitions (double the amount)*". The task self-efficacy scores for each exercise were computed by summing and averaging the ratings for each interval score to produce a value out of 10. Internal consistency was acceptable (Nunnally & Bernstein, 1994) for both scales: bench press α = .79 and leg extension α = .81.

Self-control Manipulation

Following the first set of exercises, participants completed either a congruent color word task (control) or a modified incongruent Stroop color word task (self-control depletion) for five minutes. For the modified incongruent Stroop color word task participants were presented with lists of words printed on laminated sheets of paper in which the print ink color and printed text were mismatched (e.g., ink color was 'yellow' and the word text read 'blue'). For each word presented, participants were required to ignore the text and say aloud the color of the print. In addition, when they encountered a word printed in red ink, they were required to override the general instructions and read aloud the printed word rather than saying the ink color. Control participants were presented with lists of words in which the print ink text and printed color were matched. The modified incongruent Stroop task has been used in numerous investigations as a manipulation to deplete self-control strength (e.g., Martin Ginis & Bray, 2010; Wallace & Baumeister, 2002) and has shown reliable, medium-large effect sizes (Hagger et al., 2010).

Manipulation Checks

Ratings of perceived *physical* exertion. Following each set of resistance exercise participants rated their perceived *physical* exertion using Borg's CR-10 scale (Borg, 1998) in order to determine the extent to which they exerted their maximum effort.

Ratings of perceived *mental* exertion. Participants rated their perceived *mental* exertion following performance of the Stroop task using an adapted version of Borg's (1998) CR-10 scale. Participants rated how much *mental* effort was required to perform the Stroop task on a scale ranging from 0 (nothing at all) to 10 (absolute maximum). Numerous studies have used this scale when assessing perceived mental exertion (e.g., Bray, Graham, Martin Ginis, & Hicks, 2012).

Potential covariates

Trait self-control. Trait self-control was assessed using the brief version of the Self-Control scale (Tangney, Baumeister, & Boone, 2004). The scale consists of 13 items rated on a 5-point Likert-type scale ranging from 1 (*not at all* *like me*) to 5 (*very much like me*) and an example item is: *"I am lazy"*. The measure demonstrated good internal consistency (α = .82).

Generalized self-efficacy. The New General Self-Efficacy scale (Chen, Gully, & Eden, 2001) was used to assess participants' perceptions of their general abilities across different situations and tasks. The scale consists of 8 items rated on a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). An example item is: "*I will be able to successfully overcome many challenges"*. Internal consistency for the scale was adequate prior to the first (α = .82) and second set (α = .90) of exercises. A trial-to-trial change score was computed to assess if generalized self-efficacy differed between conditions following depletion.

Task motivation. Motivation for performing the resistance exercises was assessed using the 5-item effort and importance subscale from the Intrinsic Motivation Inventory (Ryan, 1982) prior to, and immediately following, each set of exercises. The effort and importance subscale is a 5-item 7-point Likert-type scale ranging from 1 (*not at all true*) to 7 (*very true*). For the pre-task measure each item was prefaced with the following stem "*For the exercise tasks I am about to do*". An example item is: *"I am going to put a lot of effort into these exercises*". For the post-task measure each item was prefaced with the following stem "*For the exercise tasks task I just completed*". An example item is: *"It was important for me to do well on those exercises"*. Internal consistency estimates for the pre-task and post-task scales were good (α's > .72).

Mood and arousal. The Brief Mood Introspection Scale (Mayer & Gaschke, 1988) was used to gauge levels of mood (pleasant/unpleasant subscale) and arousal (arousal/calm subscale) following the Stroop task. Using a 7-point Likert scale ranging from 1 (*definitely do not feel*) to 16 (*definitely feel*), participants rated 16 items (e.g., happy, tired) describing how they felt, at that time. Internal consistency for the subscales was acceptable (α's > .77)

Procedure

During the intake visit at the laboratory, informed consent was obtained and parameters of the study were explained. Participants completed the Godin Leisure Time Exercise Questionnaire and the brief Self-Control scale followed by a 5-minute warm-up ride on a cycle ergometer at a resistance of 50 watts and pedaling speed of 50-70 revolutions per minute (RPM). Proper lifting techniques (based on the instructions listed on each machine) were then demonstrated on two plate and pulley resistance exercise machines (Universal Gym^{TM}). Predicted 1RM was then calculated for each participant for each exercise using the procedures described above and the experimental testing session was scheduled for 72 hours later. Participants were asked refrain from completing any form of resistance exercise or strenuous physical activity between sessions.

The testing session began with a 5 min warm-up on a stationary cycle ergometer at 50 watts (at 50-70 RPM). Participants then completed a warm-up set (10 repetitions) on each of the bench press and leg extension machines at 25% of their predicted 1RM. Participants were informed they would be completing one set on bench press at 60% of their 1RM and then one set on leg extension at 40% of their 1RM to exhaustion with 1 min of rest between exercises. Prior to performing the first set of exercises, participants rested for five minutes and completed the New General Self-Efficacy scale and the pre-task effort and importance subscale. A research assistant then provided a brief demonstration of each exercise while performing the random number identification task (as described above). Participants completed the first set of bench press, rested for one minute, and then the first set of leg extension. Participants provided ratings of perceived *physical* exertion immediately following each set. After the leg extension set there was a one-minute and 30-second transition interval prior to beginning the Stroop task. During this time participants were seated in a chair at a desk and completed the post-task the effort and importance subscale, were randomized (stratified by gender) using a random number generator (www.random.org) to either the depletion (incongruent Stroop task) or control (congruent Stroop task) condition.

Participants then completed their respective experimental manipulation for five minutes, after which they provided a rating of perceived *mental* exertion and completed the Brief Mood Introspection Scale, the SSCSS, the New General Self-Efficacy scale, the two task self-efficacy scales, and the pre-task effort and importance subscale relating to the second sets of exercises. The time allocated to questionnaire completion and rest following the Stroop task was standardized at six minutes. Participants then completed the second set of bench press, rested for one minute, and then the second set of leg extension exercises. Participants provided ratings of perceived *physical* exertion immediately following each set. Upon completion of the final set of leg extension, they completed the post-task effort and importance subscale, were debriefed, and remunerated $15. The study was approved by an Institutional Research Ethics Board.

Data Analysis

Descriptive statistics were computed for the study variables. Separate one-way analysis of variance (ANOVA) models were computed to assess differences in means between conditions for the demographic variables, potential covariates, and manipulation checks. The main hypotheses predicting between-group differences in bench press and leg extension repetition change, state self-control capacity, and task self-efficacy (for bench press and leg extension), were evaluated using one-way ANOVAs. Bivariate (Pearson's *r*) correlation coefficients were computed for the relationships between condition and the dependent variables. Tests for indirect (mediation) effects were assessed using the *PROCESS* software macro (Hayes, 2013). All statistical analyses were conducted using SPSS version 20.

Results

Demographics and Potential Covariates

Descriptive statistics, ANOVA summaries, and effect sizes for demographics and potential covariates are shown, by group, in Table 1. There were no significant differences between conditions (*p*s > 0.05) for any of the measured variables.

Manipulation Checks

Descriptive statistics, ANOVA summaries, and effect sizes for the manipulation check measures for the sample are shown, by group, in Table 1. Consistent with the intent of the self-control depletion manipulation, participants in the depletion condition reported significantly greater ratings of perceived *mental* exertion following the Stroop task (p = <.001, d = 2.48), completed significantly fewer trials (p = <.001, d = 2.59) and made more errors (p = <.001, d = 1.92) when compared to controls. Ratings of perceived *physical* exertion did not differ between the groups (*p*s > .05) following the resistance exercises indicating both groups exerted maximum effort while performing the tasks.

Main Analyses

Descriptive statistics, ANOVA summaries, and effect sizes for the dependent measures for the sample are shown, by group, in Table 2. Consistent with our hypotheses, participants in the depletion condition completed 3.76 fewer repetitions on bench press on the post-test, while the control group completed 0.16 more repetitions. This difference was significant with a large effect size (p = <.001, d = 1.28). The depletion condition also completed 2.96 fewer repetitions on leg extension on the post-test compared to controls who increased by 0.72 repetitions. This difference was also a large and significant effect (p = .002, d = 0.91).

Consistent with hypotheses, participants in the depletion condition reported lower task self-efficacy scores for both bench press (*p* = .002, *d* = 0.94) and leg extension (*p* = .014, *d* = 0.72) compared to controls. The depletion group also reported lower ratings on the SSCCS compared to controls (*p* = .02, *d* = 0.69).

Indirect (Mediation) Effects

Preliminary examination of the correlation coefficients (Pearson's *r*) between experimental conditions, bench press and leg extension repetition change, bench press and leg extension task self-efficacy, and state self-control capacity, showed significant ($p < .05$) bivariate relationships between most of the variables, with *r*(50)'s ranging from 0.04-0.88 (See Table 3).

To evaluate our hypothesis that state self-control capacity mediates the effect of self-control depletion on task self-efficacy (for bench press and leg extension), indirect effects analyses were computed (depicted in Figure 1a). Indirect effects analyses were also computed to evaluate our hypothesis that state self-control capacity and task self-efficacy (bench press and leg extension) sequentially (serial) mediates the effect of self-control depletion on physical self-control performance (the change in repetitions from Trial 1 – Trial 2 on bench press and leg extension) (depicted in Figure 1b). As recommended by Hayes and Scharkow (2013), bias-corrected bootstrap procedures utilizing 10,000 simulations were computed for each mediation analysis the *PROCESS* software macro (Hayes, 2013). Kappa-squared ($_k{}^2$) values (Preacher & Kelly, 2011), which represent the proportion of the maximum possible indirect effect that was accounted for by the mediator (state self-control capacity) in the model, was also computed to provide effect size estimates. Direct effect statistical summaries from the mediation analyses are shown in Table 4.

In the first mediation analysis, bench press task self-efficacy was specified as the dependent variable with experimental condition (control/depletion) as the independent variable and state self-control capacity as the mediator. Results showed a significant indirect (mediation) effect for state self-control capacity (95% C.I. = -0.90, -0.10, $_{k}^{2} = 0.17$). The second mediation analysis specified leg extension task self-efficacy scores as the dependent variable with experimental condition (control/depletion) as the independent variable and state self-control capacity as the mediator. Results also showed a significant indirect effect for state self-control capacity (95% C.I. = -0.87, -0.06, $_{k}^{2} = 0.12$).

In the first serial mediation analysis, bench press repetition change was specified as the dependent variable with experimental condition (control/depletion) specified as the independent variable, and state self-control capacity (M_1) and bench press task self-efficacy (M_2) as the mediators. As hypothesized, results indicated a significant serial mediation effect (95% C.I. = -0.96, -0.09). The simple indirect effect for bench press task self-efficacy (paths a_2, b_2) was significant (95% C.I. = -1.50, -0.11) while the indirect effect for the state self-control capacity (paths a_1, b_1) was not significant (95% CI = -1.09, 0.46).

In the second serial mediation analysis, leg extension repetition change was specified as the dependent variable with experimental condition (control/depletion) specified as the independent variable, and state self-control capacity (M_1) and leg extension task self-efficacy (M_2) as the mediators. Again, as hypothesized, results showed a significant serial mediation effect (95% C.I. = -1.54, -0.09). The indirect (simple mediation) effects for state self-control capacity (paths a_1, b_1) and leg press task self-efficacy (paths a_2, b_2) were also significant (95% C.I. = 0.10, 2.26 and -3.02, -0.09, respectively).

Discussion

We investigated the effects of self-control strength depletion on subjective fatigue, task self-efficacy, and physical self-control performance. It was hypothesized that self-control depletion would have negative aftereffects on state self-control capacity, task self-efficacy, and physical self-control endurance performance (repetitions completed on bench press and leg extension). We also predicted that state self-control capacity and task self-efficacy would sequentially mediate the effect of self-control depletion on physical self-control endurance performance. Specifically, it was hypothesized that self-control depletion would have an indirect effect on task self-efficacy through state self-control capacity and that, when the mediation model was extended to include task performance, state self-control capacity and task self-efficacy would have sequential indirect effects accounting for the relationship between the self-control strength manipulation (control/depletion) and later self-control performance (Figure 1b).

Consistent with the hypotheses, state self-control capacity, task self-efficacy, and physical self-control endurance performance were each negatively affected following self-control strength depletion. These findings contribute to a growing body of evidence showing task self-efficacy is reduced following exertion of self-control on a prior task (Chow et al., 2015; Graham & Bray, in press). The results also align with the vast literature showing expenditure of self-control resources on tasks requiring cognitive self-control leads to performance impairments on tasks requiring physical stamina (e.g., Bray et al., 2008; Dorris, Power, & Kenefick, 2012; Martin Ginis & Bray, 2010). However, these data are the first to show performance is reduced on resistance exercises. The findings that participants reached volitional exhaustion performing significantly fewer repetitions of both exercises in the depletion condition highlights the self-control demands of resistance exercise. Given resistance exercise is a cornerstone of fitness training for athletes and recreational exercisers, these findings may have important practical implications for training such that coaches, trainers and exercisers should be conscientious that exercise performance may be compromised by prior exertion of self-control, which may affect progress during training.

The finding that state self-control capacity was reduced following the incongruent Stroop task also aligns with prior research on self-control depletion (e.g., Smolders & Kort, 2014) in what may be an important and underappreciated aspect of self-control depletion research. That is, the lower scores on the SSCCS shown in this study, and others, suggests prolonged exertion of self-control results in an interoceptive feeling state reflecting a specific form of tiredness or subjective fatigue. Given prior research has struggled to identify a self-control resource, subjective fatigue provides an important avenue for future researchers to expand in order to investigate psychophysiological sequelae of prior enactments of self-control.

The effects of the self-control depletion manipulation on state self-control capacity, task self-efficacy and task performance also set the stage for testing our theoretical model that the increased subjective fatigue caused by the incongruent Stroop task would lead to reductions in self-efficacy which would, in turn, account for deterioration in task performance. As we predicted, the analyses for both resistance exercise tasks clearly showed the effects of the self-control depletion manipulation on task self-efficacy were mediated by state self-control capacity and when the model was extended to include task performance, sequential mediation was also evident.

The findings supporting a sequential mediation process through self-efficacy represent a critical advancement for research on the limited resource model of self-control proposed originally by Baumeister et al. (1998) and recently refined by Baumeister (2014). To this point, there has been little theory-guided effort towards identifying causal mechanisms that account for why performance deteriorates on sequential tasks that require self-control. The strength model contends there is a fatigable internal resource that is similar to a muscle; however, the biological nature of the resource is contentious (e.g., Beedie & Lane, 2012; Kurzban, 2010; Molden et al., 2012) and the muscle analogy is over-simplified

(Richter & Stanek, 2015), which has provided researchers with little insight as to what self-control depletion really is and how it occurs. The present study provides convincing evidence of a causal process mediated by self-efficacy and its theorized antecedent of subjective fatigue. Future research is encouraged to test the sequential mediation model proposed in the present study when examining the effects of self-control depletion on the performance of other tasks requiring self-control.

Recent writings by Chow et al. (2015) and Graham and Bray (in press) provide extensive arguments that task self-efficacy can indirectly account for the mixed evidence produced by research on the strength model in recent years. For example, substantial evidence indicates that numerous factors such as positive affect (Tice, Baumeister, Shmueli, & Muraven, 2007), rewards (Muraven & Slessareva, 2003), and beliefs about the limits of one's willpower (Job, Dweck, & Walton, 2010) can modify the magnitude of the aftereffects of self-control depletion. Self-efficacy provides a logical and theory-based mechanism that can explain such effects. Contemporary theorizing, by numerous authors (e.g., Inzlicht & Schmeichel, 2015; Kurzban et al., 2013), highlight a critical role for motivation rather than resource depletion in accounting for sequential deficits in self-control over repeated tasks. Self-efficacy is a cognition that may reflect motivational shifts brought on by opportunity cost assessments, rewards or other situational factors that are associated with attempts to exert control over behavior.

Although task self-efficacy appears to play a key role in performance of sequential self-control tasks, it is also necessary to expand thinking about how self-efficacy is affected by prior self-control activation. In this study, we provide evidence that increased subjective fatigue is an antecedent to declining self-efficacy; however, research exploring the biological source of fatigue is needed. There is strong evidence that physiological alterations occur during and immediately following performance of tasks requiring self-control. For example, neurophysiological processes relating to cerebral blood flow are altered by tasks that require self-control (Lopez, Vohs, Wagner, & Heatherton, 2015). Autonomic nervous system activity (Segerstrom & Solberg Nes, 2007) as well as peripheral muscle activation patterns (Bray et al., 2008) are altered following performance of tasks that require self-control. It is plausible that such neurophysiological changes trigger interoceptive sensations of subjective fatigue.

Given that the neurophysiological changes brought on by prior actions requiring self-control may be automatic and directly influence subjective feeling states of fatigue, another relevant question for future research pertains to the role of task self-efficacy in determining subsequent behavior. For instance, self-efficacy may merely be a passive gauge reflecting a perception about an underlying physiological state of diminished resources within an organism that can perform no differently than its resources will allow. Alternatively, self-efficacy may be a motivational intersection where neurophysiological processes, affective sensations, and situational perceptions combine to determine how much self-control one will ultimately invest in a task. We believe the collective evidence suggests the latter; but it is essential that future research take focus on self-efficacy as part of a causal process affecting self-control to determine how this perception may shape self-control in ways that may be dependent upon or independent of self-control depletion.

Results of the present study support our sequential mediation model and the roles of subjective fatigue and task self-efficacy as mediators of self-controlled performance of resistance exercise. However, there are a number of limitations that should be noted. For example, although participants in our study had previous experience with resistance exercise they were not routinely engaging in resistance exercise which may limit generalizability of the findings to relatively inactive individuals. Also, while the Stroop task used to manipulate self-control was well-suited for a laboratory study, it lacks ecological relevance to exercise performance environments and future studies should seek to incorporate self-control manipulations that simulate tasks that may occur in sport or exercise performance contexts (e.g., emotion regulation, complex decision making).

In conclusion, the present study has provided the first evidence that prior self-control exertion negatively affects resistance exercise performance through sequentially-mediated pathways involving subjective fatigue and task self-efficacy. These results suggest that subjective fatigue is an antecedent to reduced self-efficacy and self-control performance following self-control depletion and future research is encouraged to test the sequential mediation model proposed in this study as well as other sequential mediation models that explore potential biological and psychological sources of subjective fatigue.

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Table 1

Comparison of Age, Potential Covariates, and Manipulation Checks by Condition

	Depletion (*n* = 25) *M* (*SD*)		Control (*n* = 25) *M* (*SD*)		*F*	*p*	*d*
Age	21.24	(3.27)	20.72	(2.35)	0.09	.52	0.19
Bouts of MVPA/week	3.32	(2.13)	3.28	(1.77)	0.05	.94	0.02
Potential Covariates							
Brief Self-Control scale	43.84	(7.78)	43.94	(7.36)	0.02	.96	0.01
NGSE pre-Trial 1	3.84	(0.45)	3.96	(0.46)	0.95	.34	0.26
NGSE Δ	-0.08	(0.43)	-0.05	(0.32)	0.08	.78	0.08
BMIS pleasantness	13.55	(12.29)	19.60	(12.24)	3.04	.09	0.49
BMIS arousal	25.41	(4.92)	23.16	(5.47)	2.34	.13	0.43
IMI pre-trial 1	6.28	(0.58)	6.17	(0.73)	0.36	.55	0.17
IMI post-trial 1	6.15	(0.70)	6.10	(0.74)	0.06	.82	0.07
IMI pre-trial 2	6.25	(0.58)	6.34	(0.68)	0.24	.63	0.14
IMI post-trial 2	6.34	(0.67)	6.38	(0.64)	0.05	.83	0.06
Manipulation Checks							
Stroop trial completed	254.88	(52.03)	475.52	(108.62)	83.90	<.001	2.59
Stroop errors	11.40	(7.91)	0.64	(0.76)	45.83	<.001	1.92
RPME	6.66	(1.74)	2.30	(1.77)	77.15	<.001	2.48
Bench press 1 RPE	7.76	(1.23)	7.90	(1.49)	0.13	.72	0.10
Leg extension 1 RPE	8.30	(1.35)	8.08	(1.12)	0.39	.53	0.18
Bench press 2 RPE	8.16	(1.34)	8.18	(1.38)	0.003	.96	0.02
Leg extension 2 RPE	8.22	(1.57)	8.64	(1.11)	1.19	.28	0.31

Note: *M* = mean, *SD* = standard deviation, *d* = Cohen’s *d* (effect size), MVPA = moderate-vigorous physical activity, NGSE = new general, Δ = trial-to-trial change, BMIS = brief mood introspection scale, IMI = intrinsic motivation inventory (effort and importance subscale). RPME = ratings of perceived *mental* exertion, RPE = ratings of perceived *physical* exertion.

Table 2

Bench Press and Leg Extension Repetitions, Trial-to-Trial Change Scores, Self-Control Capacity Scores, and Self-efficacy Scores by Condition

	Depletion *n* = 25 *M* (*SD*)		Control *n* = 25 *M* (*SD*)		*F*	*p*	*d*
Bench press predicted 1RM (lbs)	120.80	(53.11)	125.84	(64.97)	0.09	.77	0.08
Leg extension predicted 1RM (lbs)	176.48	(67.04)	167.96	(55.49)	0.24	.63	0.14
Bench press Trial 1 reps	24.88	(5.11)	24.72	(6.48)	0.01	.92	0.03
Leg extension Trial 1 reps	27.84	(7.20)	26.12	(6.53)	0.78	.38	0.25
Bench press Trial 2 reps	21.12	(2.88)	24.88	(7.50)	4.96	.03	0.66
Leg extension Trial 2 reps	24.88	(6.98)	26.84	(7.13)	0.96	.33	0.28
Bench press Trial 1 – Trial 2 rep Δ	-3.76	(3.13)	0.16	(3.00)	20.49	<.001	1.28
Leg extension Trial 1 – Trial 2 rep Δ	-2.96	(3.74)	0.72	(4.36)	10.26	.002	0.91
SSCCS scale	46.84	(8.91)	53.12	(9.18)	6.03	.02	0.69
Bench press task self-efficacy	2.80	(0.88)	3.90	(1.40)	10.94	.002	0.94
Leg extension task self-efficacy	2.94	(1.15)	3.94	(1.58)	6.45	.014	0.72

Note: *M* = mean, *SD* = standard deviation, *d* = Cohen’s *d* (effect size), 1RM = one repetition maximum, lbs = pounds, reps = repetitions, Δ = trial-to-trial change, SSCCS = state self-control capacity scale.

Table 3

Bivariate Correlations (Pearson's r) between Experimental Condition, Bench Press and Leg Extension Trial-to-trial Change Scores, and Bench Press and Leg Extension Task Self-efficacy Scores, and State Self-control Capacity Scale scores

	1	2	3	4	5
1. Condition (0 = control, 1 = depletion)					
2. State Self-Control Capacity Scale	-.34*				
3. Bench press task self-efficacy	-.43**	.56**			
4. Leg extension task self-efficacy	-.34**	.42**	.88**		
5. Bench press Trial 1 – Trial 2 rep Δ	-.55**	.36*	.52**	.34*	
6. Leg extension Trial 1 – Trial 2 rep Δ	-.42**	.04	.41**	.49*	.32*

Note: * = *p* < .05, ** = *p* < .01, rep = repetitions, Δ = trial-to-trial change.

Table 4

Regression Model Summaries for Single and Sequential (Serial) Mediation Models

		Consequent										
		M_1 (State self-control capacity)				M_2 (Bench press self-efficacy)				Y (Bench press rep Δ)		
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (Condition)	a_1	-6.28	2.56	.018	a_2	-0.70	0.31	0.029	c'	-2.82	0.91	.004
M_1 (State self-control capacity)		--	--	--	a_3	0.06	0.02	<.001	b_1	0.02	0.05	.756
M_2 (Bench press self-efficacy)		--	--	--		--	--	--	b_2	0.91	0.41	.031
Constant	i_{M1}	53.12	1.81	<.001	i_{M2}	0.53	0.90	.56	i_Y	-4.27	2.54	.099
		$R^2 = 0.11$				$R^2 = 0.38$				$R^2 = 0.40$		
		$F(1, 48) = 6.03, p = .018$				$F(2, 47) = 14.44, p = <.001$				$F(3, 46) = 10.11, p = <.001$		

		Consequent										
		M_1 (State self-control capacity)				M_2 (Leg extension self-efficacy)				Y (Leg extension rep Δ)		
Antecedent		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*		Coeff.	*SE*	*p*
X (Condition)	a_1	-6.28	2.56	.018	a_2	-0.66	0.39	.099	c'	-3.02	1.12	.009
M_1 (State self-control capacity)		--	--	--	a_3	0.05	0.02	.015	b_1	-0.13	0.06	.037
M_2 (Leg extension self-efficacy)		--	--	--		--	--	--	b_2	1.49	0.40	<.001
Constant	i_{M1}	53.12	1.81	<.001	i_{M2}	1.13	1.14	.329	i_Y	1.85	3.18	.563
		$R^2 = 0.11$				$R^2 = 0.22$				$R^2 = 0.38$		
		$F(1, 48) = 6.03, p = .018$				$F(2, 47) = 6.76, p = .003$				$F(3, 46) = 9.21, p = <.001$		

Note: rep = repetition, Δ = trial-to-trial change. Coeff. = regression coefficients, *SE* = standard error.

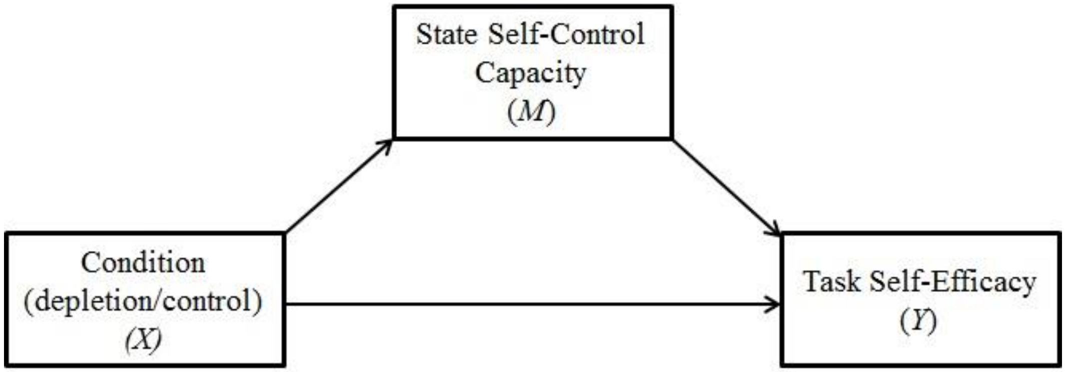

Figure 1a. Self-control depletion – task self-efficacy mediation model

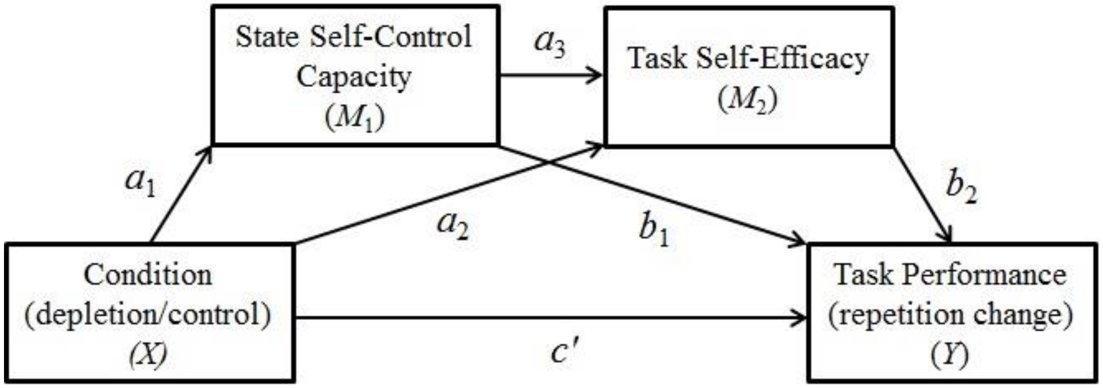

Figure 1b. Self-control depletion –performance serial mediation model

CHAPTER 4:
Effects of performance feedback on self-efficacy and exercise performance are moderated by self-control strength depletion

Preamble

Effects of performance feedback on self-efficacy and exercise performance are moderated by self-control strength depletion is the third study in the dissertation series. This study investigates the independent and interactive effects of self-control strength depletion and normative performance feedback on self-efficacy and physical self-controlled exercise performance. The main purpose of this study was to investigate the effects of performance feedback on self-efficacy and self-controlled performance of a muscular endurance task. A secondary objective was to investigate the effects of feedback on self-efficacy and self-controlled performance under conditions of self-control strength depletion (Baumeister, 2014).

The manuscript is currently under review for publication in the *Journal of Sport & Exercise Psychology* and has been formatted for this dissertation.

Contribution of Study 3 to overall dissertation

Study 3 replicated the findings from Studies 1 and 2 showing that self-control depletion negatively affects task self-efficacy and self-control performance. Study 3 builds on Studies 1 and 2 as well as providing unique contributions to the literatures examining self-regulation and self-control behaviour based on theorizing found within control theory (e.g., Carver & Scheier, 2011), self-efficacy theory (Bandura, 1997), and the strength model of self-control (Baumeister, 2014). In the no depletion conditions, high feedback led to lower self-efficacy and a negative change in performance while low feedback led to higher self-efficacy and performance. However, the reverse was seen following self-control depletion. Findings support self-efficacy theory insofar as self-efficacy is a motivational perception that guides behaviour. Findings also support predictions of control theory when self-control is intact, but suggest feedback information is processed differently when self-control resources are compromised.

Abstract

The purpose of this study was to investigate the independent and interactive effects of self-control strength depletion and normative performance feedback on task self-efficacy and self-controlled physical endurance. Participants (N = 78) completed two isometric handgrip endurance trials, separated by manipulations of self-control strength and normative performance (high/low) feedback. Results showed an interaction between feedback and self-control depletion. For the control groups not depleted of self-control strength, high feedback led to lower task self-efficacy and performance whereas low feedback led to higher task self-efficacy and performance. However, in the depletion groups, high feedback led to higher self-efficacy and performance while low feedback resulted in lower self-efficacy and performance. Findings support predictions of control theory when self-control is intact, but suggest feedback information is processed differently when self-control strength is depleted. Researchers and practitioners should be considerate of participants' self-control depletion when providing performance feedback to manipulate self-efficacy and exercise performance.

Effects of Performance Feedback on Self-Efficacy and Physical Performance are Moderated by Self-Control Strength Depletion

Self-regulation or self-control involves overriding or altering short-term temptations in order to attain desired standards (Baumeister, 2014; Carver & Scheier, 2011). Self-control is a key determinant of many positive behavioral outcomes (Baumeister, Heatherton, & Tice, 1994; Tangney, Baumeister, & Boone, 2004), some of which include school and work achievement (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012) as well as sport and exercise performance (e.g., Englert & Bertrams, 2014; Martin Ginis & Bray, 2010).

One influential perspective that has been advanced to explain self-regulation processes is control theory (Carver & Scheier, 1998; Powers, 1973). Control theory proposes self-regulation occurs as a cybernetic behavioral feedback loop consisting of two phases. In the “monitoring” phase, people use internal and environmental feedback to evaluate their current state relative to a desired standard or goal. In the “operation” phase, people either maintain or make adjustments to their state depending on whether or not the feedback received indicates there is a discrepancy between the current and desired states. In simple terms, if feedback monitoring shows the current state is at, or above, the desired standard (high feedback) then self-control operations are not engaged and resources necessary to alter behavioral control are conserved. However, if the current state is below the desired standard (low feedback), self-control resources are expended in an effort to change behavior and reduce or eliminate the discrepancy (e.g., Vancouver, Gullekson, Morse, & Warren, 2014). Once feedback indicates the discrepancy has been eliminated, self-control operations are curtailed; at least until another discrepancy is detected. It is critical to note that "this view pertains to current, ongoing episodes" of self-regulation rather than behaviors that are spaced over longer periods of time (Carver & Scheier, 2011, p. 10).

A considerable body of research on goal setting and self-monitoring, going back to the 1960's (e.g., Locke, 1968), supports the importance of the monitoring phase of control theory for behavioral self-regulation in multiple domains including work, nutrition, exercise, and sport performance (e.g., Michie, Abraham, Whittington, & Gupta, 2009; Kyllo & Landers, 1995; Locke, Shaw, Saari, & Lantham, 1981). In contrast, research on the operation phase has emerged more recently and was influenced by the development of the strength model of self-control (Baumeister, 2014). According to the strength model, the energy required by the operation phase of the behavioral regulation process is drawn from a limited internal resource. Peoples' abilities to effectively self-regulate are determined by the amount of resources available. Consequently, when resources are at full strength, self-control operations can be executed more effectively compared to when resources are depleted. The strength model has received a great deal of support from research showing people are less effective at performing tasks requiring self-control for some period of time after performing other tasks that required (and supposedly depleted) self-control resources (for a meta-analysis see Hagger, Wood, Stiff, & Chatziarantis, 2010).

Although feedback and self-control strength are integral components of control theory, as far as we are aware, no studies have investigated how these processes may interact. Of particular interest is how different types of feedback may influence behavior when self-control resources are depleted. Revisions to the strength model indicate the finite resources utilized for self-control operations are strategically managed and more likely to be conserved when they have been depleted (Baumeister, 2014). Therefore, people may alter their allocation of resources in response to feedback differently when they are depleted. For example, if high feedback leads to self-control withdrawal under normal circumstances, high feedback may prompt greater withdrawal when depleted because there is a greater need for resource conservation. Similarly, when self-control resources are depleted, people may temper their self-control investment following low feedback and not attempt to increase their performance as much as they would when not depleted. This question has theoretical relevance in terms of understanding cognitive and behavioral processes through which feedback may be interpreted and acted upon. It is also a practical question as many sustained or repetitive behaviors involved in sport training or fitness-related exercise may last lengthy periods of time and require ongoing self-regulatory operations that do not allow self-control strength resources to fully recover until the session is completed. Thus, it is of both theoretical and practical relevance to investigate whether performance feedback leads to different outcomes when one is depleted of self-control strength.

Exploring the behavioral outcomes associated with performance feedback and self-control strength depletion was of primary interest in this study. However, we also examined the role of self-efficacy in relation to feedback, self-control depletion, and task performance. Self-efficacy refers to "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is positively associated with task performance in multiple domains including sport and exercise (e.g., Moritz, Feltz, Fahrback, & Mack, 2000). Self-efficacy also plays a critical role in the effective self-regulation of behavior such that when goals or standards are established we draw on self-efficacy beliefs to inform our decision of how much effort and persistence to put forth towards goal attainment (Bandura, 1997). Two recent studies have revealed that self-efficacy is affected by self-control strength depletion. In a series of laboratory studies using cognitive self-control tasks, Chow, Hui, & Lau (2015) showed that task self-efficacy was reduced following self-control depletion and accounted for negative changes in performance. In a study of physical self-control, Graham and Bray (in press) found self-control depletion was associated with lower task self-efficacy, which mediated the effect of depletion on physical endurance. Thus, self-efficacy appears to play an important role within the self-control depletion – performance relationship.

A major pillar of self-efficacy theory is that positive performance feedback based on mastery experience or verbal persuasion leads to greater self-efficacy, which in turn, leads to enhanced effort and performance (Bandura, 1997). However, research into the effects of feedback on self-efficacy and performance shows an inconsistent pattern of results. Some studies that have experimentally manipulated self-efficacy through normative performance feedback have shown high feedback leads to increased self-efficacy and exercise performance (e.g., Hutchison, Sherman, & Martinovic, 2008). Whereas, other studies have shown that high feedback leads to increased self-efficacy but exercise performance does not differ between groups that receive high and low feedback (e.g., Motl, Konopack, Hu, & McAuley, 2006). Furthermore, the effects of feedback on exercise performance have been mixed with studies showing improved performance following high feedback (e.g., Weinberg, Gould, & Jackson, 1979) and others showing no changes following low feedback (e.g., Feltz & Riessinger, 1990). Given these mixed findings, further research is needed to investigate the effects of normative feedback on self-efficacy and performance of exercise tasks requiring self-regulation.

Although not in the area of exercise science, it is also important to acknowledge that several studies based on control theory have shown effects opposite to those predicted by self-efficacy theory. For instance, several studies have found that when study participants performed a series of sequential tasks, high feedback about performance on the earlier tasks led to high self-efficacy but a reduction in performance, whereas low feedback led to lower self-efficacy and an increase in performance (e.g., Vancouver, Thompson, Tischner, & Putka, 2002; Vancouver et al., 2014). The effects of feedback on self-efficacy were those predicted by self-efficacy theory; however, feedback affected performance in line with control theory predictions. These findings and others (e.g., Sitzmann & Yao, 2013) suggest the strong positive self-efficacy – performance relationship reviewed in the literature may be underestimated as sequential tasks that require self-regulation of behavior may show a negative or null self-efficacy – performance relationship even when performance feedback has a positive effect on self-efficacy.

As was the case for feedback and self-control strength, understanding the effects of performance feedback on self-efficacy and performance of tasks involving self-regulation of physical effort has both theoretical and practical implications. Indeed, coaches, trainers and other interventionists use feedback as a strategy to manipulate self-efficacy and performance of athletes and other performers (for reviews see Ashford, Edmunds, & French, 2010; Samson & Solmon, 2011). Given that self-control strength may be depleted to varying degrees during exercise or training sessions, investigation of potential interactions between performance feedback and self-control depletion may yield important information for sport and exercise practitioners who aim to optimize self-efficacy and physical performance.

The purpose of the present study was to investigate the independent and interactive effects of self-control strength depletion and normative performance feedback on task self-efficacy and self-controlled physical endurance performance. The study design involved two lab visits that were separated by 48 hours. During the first visit, participants were given experience with the exercise task (isometric handgrip endurance) so they could better gauge their task self-efficacy beliefs during the experimental session. During the experimental session, they completed two handgrip endurance trials that were separated by manipulations of self-control strength and normative performance feedback. In one condition, participants performed a task to deplete self-control, while in the other condition they performed a control task that would not deplete self-control strength. Participants were then given normative feedback (high or low) or no feedback (control) about their performance on the first endurance trial, after which task self-efficacy for the second endurance trial was assessed and then the second endurance trial was performed.

Based on previous findings (Graham & Bray, in press), the first hypothesis was that self-control strength depletion would have negative effects on self-efficacy and task performance. Drawing from control theory (Carver & Scheier, 2011), we predicted high feedback would lead to lower performance than low feedback when participants were not depleted of self-control strength. Based on the premise that self-control resources are more stringently conserved when people are depleted (Baumeister, 2014), we predicted task performance would be lower for both high and low feedback conditions compared to the no depletion conditions. Lastly, based on self-efficacy theory (Bandura, 1997), we predicted that high feedback would lead to higher task self-efficacy and low feedback to lower task self-efficacy in the depletion and control conditions.

Method

Participants and Design

The sample was comprised of 78 university students (49 women) with a mean age of 20.51 (*SD* = 3.91) years. Recruitment criteria specified participants must have engaged in no resistance training exercise during the previous six months, no more than 90 minutes of moderate-vigorous physical activity (MVPA) per week, and not be engaged in sport as a competitive (e.g., university varsity) athlete.

The design was a single-blind, 2 (control/depletion) by 3 (no feedback/high feedback/ low feedback) factorial. Participants were sequentially randomized to one of six conditions: control/no feedback (*n* = 11), control/high feedback (*n* = 13), control/low feedback (*n* = 12), depletion/no feedback (*n* = 13), depletion/high feedback (*n* = 14), depletion/low feedback (*n* = 15). The primary hypotheses related to a 2 X 3 interaction for which a sample-size calculation (G*Power version 3.1.9.2; Faul, Erdfelder, Buchner, & Lang, 2009), based on large effect sizes, power = .80, and $\alpha = 0.05$, indicated a sample of *N* = 64 was sufficient for the analysis. The anticipation of large effect sizes was based on previous research investigating task self-efficacy and performance following self-control depletion (Graham & Bray, in press) as well as following feedback manipulations (Vancouver et al., 2014).

Measures

Physical self-control. The change in physical self-control performance (time to failure) over two trials of a muscular endurance task served as the criterion indicator of self-control. Participants initially performed two, four-second, 100% maximum voluntary contractions (MVCs), separated by three minutes, using a handgrip dynamometer with a graphic computer interface (model MLT003/D; PowerLab 4/25T; ADInstruments, Colorado Springs, CO). The greatest peak force value (from a one-second window) from the greater MVC was then used to determine the 50% MVC target value for the endurance trials. To perform the endurance task, participants squeezed the handgrip dynamometer and were provided visual feedback on a 17-inch computer monitor in the form of a force tracing (i.e., a real-time graphed line). Participants were instructed to sustain a handgrip squeeze for as long as possible that kept their active force tracing line at, or slightly above, a static target line (set at 50% MVC). If the force tracing fell below the target line during the trial, the experimenter instructed participants to “squeeze harder so the force tracing line stays above the static red line”. The trial ended when the force tracing line fell below the target line for longer than two seconds or when participants voluntarily stopped. The experimenter followed a detailed script throughout the experimental sessions and no motivational feedback or verbal encouragement was provided at any time.

Participants had no knowledge of the magnitude of force generation or elapsed time during the endurance trials. Physical self-control performance was represented by the change in duration (seconds) of the isometric handgrip squeeze from the first to the second trial (Trial 2 duration – Trial 1 duration).

Task self-efficacy. An eight-item scale assessed self-efficacy for task performance on the second endurance trial. Adhering to recommendations by Bandura (2006), each item was prefaced with the stem "*Compared to how long I went last time, I am confident that I can hold on for…"* The individual items represented hierarchical gradations of performance that were relative to the participant's performance on the previous trial, which began at *"25% as long (1/4 the amount)*" and increased by 25% increments to *"200% as long (double the amount)*". Participants responded to each item using an 11-point scale ranging from: 0 = *not at all confident* to 10 = *totally confident*. The task self-efficacy score was computed by averaging the eight ratings to produce a scale value out of ten. Internal consistency of the scale was good (Cronbach's α = .85).

Experimental Manipulations

Self-control strength depletion. Following the first endurance handgrip trial, participants were randomized to one of two conditions that completed either a congruent Stroop task (control) or modified incongruent Stroop task (self-control depletion) continuously for five minutes. For the modified incongruent Stroop task, participants were presented with lists of words in which the print ink color and printed text were mismatched. Participants were required to read aloud the color of the print ink and ignore the text for each word presented. In addition, when they encountered a word printed in red ink, they were required to override the general instructions and read aloud the printed word. Control participants were presented with a list of words in which the printed text and ink color and were matched. The modified Stroop task has been used in numerous investigations as a manipulation to deplete self-control strength (e.g., Graham & Bray, in press; Wallace & Baumeister, 2002).

Feedback. Participants in the feedback conditions were given bogus normative information about their performance on their first endurance trial, while control participants received no feedback. Those in the “high” feedback condition were informed their performance was at the 84th percentile of the sample, whereas those in the “low” feedback condition were informed they had performed at the 16th percentile. To increase the likelihood that the feedback was believable to participants, they were told they were the 97th participant to have completed the study and graphed calculations were presented using a spreadsheet which displayed the participant’s ID (i.e., 97) and percentile rank (i.e., either 16th or 84th) overlaid on a normal distribution curve. The following script was used in conjunction with the graphic feedback, *“I am going to show you how you compared to the past participants on the first endurance trial. I have entered your time into a spreadsheet that calculated your percentile rank. As you can see, your participant ID is 97 and your percentile rank is here, just in case you are unclear what this means I have provided a normal distribution curve* [experimenter pointed to the spot on the curve that represented their percentile rank]. *This means that you performed better (or worse) than 84% of the past participants".* Similar normative performance feedback manipulations have been used in studies of handgrip performance (e.g., Hutchison et al., 2008) and self-control depletion (e.g., Wallace & Baumeister, 2002).

Manipulation Checks

Ratings of perceived physical exertion. Participants rated their perceived *physical* exertion following each endurance trial using Borg's CR-10 scale (Borg, 1998).

Ratings of perceived mental exertion. Following the Stroop task, participants indicated how much *mental* effort was required to perform the Stroop task using an adapted version of Borg's CR-10 (Borg, 1998) scale ranging from 0 (nothing at all) to 10 (absolute maximum).

Normative rating scale. Perceived ability to hold the handgrip (at 50% MVC) was assessed prior to each handgrip endurance trial using a ten-item, 11-point, 0 (*not at all confident*) to 10 (*totally confident*) scale. The individual items represented hierarchical gradations of performance that were relative to previous study participants' (i.e., normative) performance for the upcoming endurance trial. Participants responded to the following "*Compared to other participants in this study, I am confident that I can squeeze the handgrip for longer than:*" The scale began at "*10% of the participants*" and increased by 10% intervals up to "*100% of the participant*s". The normative rating score was computed by averaging each interval score to produce a scale value out of ten. The normative rating scale was completed prior to the first endurance trial to determine participants' perceived performance standard for the task and was also completed prior to the second endurance trial as the manipulation check for the feedback manipulations. Internal consistency of the scale at both administrations was good (α > .92).

Feedback awareness scale. Prior to being debriefed, participants responded to the item *"I believed what the experimenter told me about my performance after the first endurance trial*" using a ten-point Likert-type scale ranging from 1 (*did not believe*) to 10 (*believed*).

Potential covariates

Trait self-control. The brief version of the Self-Control Scale (Tangney et al., 2004) was used to assess trait self-control. The scale consists of 13 items rated on a five-point Likert-type scale ranging from 1 (*not at all like me*) to 5 (*very much like me*). An example item is "*I am lazy*". The measure demonstrated good internal consistency (α = .81).

Mood and arousal. The Brief Mood Introspection Scale (Mayer & Gaschke, 1988) was used to gauge levels of mood (*pleasant/unpleasant* and *arousal/calm*) following the incongruent and congruent Stroop task. Participants rated 16 items (e.g., happy, calm) describing how they felt, in the moment, using a seven-point Likert-type scale ranging from 1 (*definitely do not feel*) to 7 (*definitely feel*). Internal consistency was acceptable for both subscales (α > .82).

Motivation. Motivation for performing the endurance trials was assessed prior to, and immediately following, each trial using the effort and importance subscale from the Intrinsic Motivation Inventory (Ryan, 1982). The subscale consists of five items that are rated on a Likert scale ranging from 1 (*not at all true*) to 7 (*very true*). An example item is: "*I put a lot of effort into this task"*. For the pre-task measure each item was prefaced with the following stem "*For the handgrip task I am about to do*" and an example item is: *"I am going to try very hard on this task*". For the post-task measure each item was prefaced with the following stem "*For the handgrip task I just completed*" and an example item is: *"It was important for me to do well on the task"*. Internal consistency for the scales was acceptable (α > .70).

Procedure

Upon entering the lab during the initial visit, informed consent was obtained and the brief Self-Control Scale was completed. After performing two MVCs, participants performed an endurance handgrip trial to exhaustion to gain experience with the task in order to more accurately gauge their task self-efficacy for the experimental session. Participants returned to the lab two days later for the experimental session, which began with completing the normative rating scale, the pre-task effort and importance scale, and then the first endurance trial. Participants then had two minutes to rest, during which they completed the rating of perceived *physical* exertion scale, the post-task effort and importance subscale, and were randomized to either the self-control depletion or control condition.

Participants then completed their respective self-control manipulation for five minutes. Following the self-control manipulation, there was a six-minute interval prior to the second endurance trial during which participants completed the perceived *mental* exertion scale, and the Brief Mood Introspection Scale. At this point, participants were further randomized to the high, low, or no feedback conditions and were exposed to their respective feedback manipulations. Following the feedback manipulation, they completed the normative rating scale, the task self-efficacy scale, the pre-task effort and importance scale, and then performed the second endurance trial. Upon completion of the endurance trial, they completed the perceived *physical* exertion scale, post-task effort and importance scale, feedback awareness scale, and were then debriefed and remunerated $10. An Institutional Research Ethics Board approved the study.

Data Analysis

Descriptive statistics were computed for the study variables. Separate univariate 2 (control/depletion) x 3 (high/low/no feedback), factorial ANOVAs were computed to assess differences in means between conditions for age, potential covariates, and manipulation checks. Between-group differences in physical self-control and task self-efficacy were also assessed using separate univariate 2 x 3 factorial ANOVAs. Significant interactions were decomposed and evaluated using post-hoc, univariate, contrasts between the separate condition cells.

Results

Potential Covariates

Descriptive statistics for age and potential covariates are shown, by group, in Table 1. Results revealed no differences between conditions ($p > .05$) for any of the variables.

Manipulation Checks

Descriptive statistics for the manipulation checks are shown, by group, in Table 1. Consistent with the intent of the self-control manipulation, participants in the depletion condition reported greater perceived *mental* exertion, F (1, 72) = 61.88, $p < .001$, $\eta_p^2 = .46$, completed fewer trials on the Stroop task, F (1, 72) = 221.02, $p < .001$, $\eta_p^2 = .75$, and made more errors, F (1, 72) = 133.32, $p < .001$, $\eta_p^2 = .65$, compared to controls. Consistent with the intent of the feedback manipulation, high feedback led to a greater normative rating score than low feedback, F (2, 72) = 29.87, $p < .001$, $\eta_p^2 = .61$. Ratings of perceived *physical* exertion for the handgrip trials and scores on the feedback awareness scale did not differ between groups ($p > .05$).

Main Analyses

Descriptive statistics summarizing scores for the dependent measures are shown, by group, in Table 2. For physical self-control, results showed an overall main effect for self-control depletion, F (1, 72) = 10.23, $p = .002$, $\eta_p^2 = .12$. The main effect for feedback was not significant, however, there was a significant depletion X feedback interaction, F (2, 72) = 7.70, $p = .001$, $\eta_p^2 = .18$. Results for task self-efficacy also showed a significant main effect for depletion, *F* (1, 72) = 4.92, $p = .03$, $\eta_p^2 = .06$, no main effect for feedback, and a significant interaction, *F* (2, 72) = 3.72, $p = .029$, $\eta_p^2 = .09$.

The interactions were evaluated in terms of the a-priori hypotheses by comparing differences between group means using simple contrasts (see Figure 1). As predicted by our first hypothesis, the depletion/no feedback group reported lower task self-efficacy (95% C.I. = 0.34-2.81, $p = .013$, $d = 1.06$) and performed worse (shorter time to failure) on the second endurance trial (95% C.I. = 7.04-31.30, $p = .002$, $d = 1.08$) compared to the control/no feedback group.

In line with the second hypothesis, the control/low feedback group outperformed the control/high feedback group on the second endurance trial (95% C.I. = 7.79-31.50, $p = .001$, $d = 1.23$). Contrary to our hypothesis, the control/low feedback group reported higher task self-efficacy scores than the control/high feedback group (95% C.I. = 0.12-2.30, $p = .07$, $d = 0.66$).

The third hypothesis also received partial support. That is, looking at the change in endurance time, the depletion/low feedback group had significantly lower performance than the control/low feedback group (95% C.I. = 13.95-36.89, $p < .001$, $d = 1.23$) and also reported lower task self-efficacy (95% C.I. = 0.17-2.51, $p = .025$, $d = 0.96$). However, contrary to our prediction, the depletion high/feedback group did not differ from the control/high feedback group on either endurance performance change (95% C.I. = -21.14-1.67, $p = .09$, $d = 0.60$) or task self-efficacy (95% C.I. = -1.70-0.62, $p = .36$, $d = 0.34$). However, it is interesting to note these medium-sized effects are in the direction opposite to those hypothesized, with the depletion/high feedback group outperforming the control/high feedback group.

Discussion

The present study investigated the independent and interactive effects of self-control depletion and normative performance feedback manipulations on task self-efficacy and physical self-control performance. Overall, we found mixed support for the hypotheses. In particular, evidence was obtained showing task self-efficacy for a physical endurance task is reduced following self-control depletion. We also found evidence supporting control theory in the no-depletion control groups following high and low feedback. However, results varied considerably from those predicted for the two feedback conditions following self-control strength depletion.

Consistent with the first hypothesis and previous research (Graham & Bray, in press), when not exposed to normative performance feedback, participants who were depleted of self-control strength reported lower task self-efficacy and performed worse on the second endurance trial when compared to controls. These findings add to a growing body of research suggesting self-efficacy may play a key role in determining the effects of self-control depletion on later task performance.

The results also supported the second hypothesis and control theory (Carver & Scheier, 1998), showing that high feedback led to lower performance on the second endurance trial whereas low feedback led to higher performance for participants who were not depleted of self-control strength. It is critical to note here that prior to the first endurance trial, scores on the normative rating scale showed all groups were equally confident relative to performance norms (see Table 1). As predicted by control theory, the high and low feedback manipulations highlighted discrepancies between participants' current and desired states which, in turn, led to the exertion of self-control resources for the low feedback group and withdrawal of resources for the high feedback group to eliminate the discrepancy on the second endurance trial. The latter findings are also consistent with the strength model (Baumeister, 2014) insofar as self-control resources are thought to be strategically managed depending on situational factors and, rather than needlessly expending resources, the body naturally seeks to conserve resources for future demands.

In contrast to the hypotheses based on self-efficacy theory, in the groups that were not depleted of their self-control strength high feedback led to lower task self-efficacy than low feedback. These results are contrary to theory in terms of performance feedback functioning as a straightforward determinant of self-efficacy, but must be interpreted in light of the fact that most research involving self-efficacy has not involved tasks that require participants to fully exert themselves on successive tasks. However, the results do support self-efficacy theory insofar as high task-self efficacy (in the low feedback group) was associated with greater performance compared to low self-efficacy (in the high feedback group). Thus, we suggest further research is needed to disentangle the effects of normative performance feedback on task self-efficacy.

The third hypothesis predicted downward shifts in task self-efficacy and performance that would be brought on by reductions in self-control strength. However, the results paint a different picture altogether in that the depleted participants showed the opposite reactions to feedback compared to controls. In stark contrast to the control condition, low feedback following self-control depletion undermined both task self-efficacy and performance on the second endurance trial. Although we had predicted a negative change in performance in this group compared to the control/low feedback group owing to increased motivation to conserve resources (Baumeister, 2014), we believe the magnitude of the observed changes suggests other factors may be involved.

The assertion that something more than increased resource conservation effects contribute to the self-efficacy and performance changes following self-control depletion are reinforced by the results from the depletion/high feedback group. In that group, self-efficacy and performance were higher than the control/high feedback group and higher than any group exposed to the depletion manipulation. Thus, in the short term, high feedback tempers the effects of self-control strength depletion on performance. This finding is consistent with previous research showing that increased motivation to exert self-control resources can temporarily sustain or improve performance (e.g., Graham, Bray, & Martin Ginis, 2014; Vohs, Baumeister, & Schmeichel, 2012). However, there were no between groups differences in motivation prior to, or after performing the second endurance trial, suggesting other factors must account for these findings.

One explanation for why high and low feedback led to differential effects in the depletion conditions compared to controls is that performance feedback information is internalized and processed differently when people are depleted. Attributional processes are among the most influential factors affecting how feedback information is processed (Kluger & DeNisi, 1996).

Attributions are assessed upon multiple dimensions (e.g., Weiner, 1985) and involve specific brain areas (Lieberman, 2007) that are linked to complex information processing (Hare, Camerer, & Rangel, 2009) as well as self-control processes (Lopez, Vohs, Wagner, & Heatherton, 2015). The two most common attributions for performance success and failure are ability and effort (Weiner, 1985); success being attributed to high ability and trying hard whereas failure is attributed to low ability and not trying hard (Bandura, 1997). In the present study, following high feedback, control participants may have attributed their success towards more stable internal factors (greater ability and effort) which increased their willingness to conserve self-control resources as they had already out performed almost everyone on the first trial. Whereas following low feedback, control participants may have attributed their failure to less stable internal factors (e.g., "*I didn't try my absolute hardest on the first trial*"), which increased their task self-efficacy to exert additional self-control resources and best their previous performance.

Neuroscientific evidence shows self-control depletion affects the performance of several brain areas involved in the exertion of self-control (Lopez et al., 2015) including top-down decision-making processes (Hare et al., 2009). Schmeichel, Vohs, & Baumeister (2003) have asserted that one of the functions played by self-control depletion is that information processing capacities are interfered with. Following this view, it is reasonable to suggest that feedback information may have been more superficially processed by depleted participants rather than the thorough or deeper attributional processing that would occur in the control groups. Accordingly, rather than prompting them to withdraw effort following high feedback, depleted people may have internalized that feedback as direct reinforcement that led them to invest greater effort and resources on the task (“*I performed great, I will do it again”*). Conversely, low feedback appeared to directly reinforce lower expectations for those who were depleted (“*I performed terribly, I will do it again”*), prompting them to withdraw effort rather than invest it. Thus, attributions are a considerate candidate for explaining the contrasting effects of feedback on self-efficacy and performance. Although we did not assess attributions or other cognitive processes following feedback, it is recommended that future research seek to assess how feedback information may be interpreted and acted upon differently when self-control resources are depleted compared to when they are not.

Results of the present study show the effects of performance feedback on task self-efficacy and physical endurance performance are moderated by self-control strength depletion. However, there are a number of limitations that should be discussed. For instance, the participants in our study were relatively inactive and not competitive sport performers who may be accustomed to pushing the limits of their physical endurance on a regular basis. Thus, the present findings may not apply to trained competitive athletes, who may respond to normative feedback differently. Further research involving trained performers and utilizing other sport and exercise tasks is necessary to enhance the ecological validity of the present findings. Although normative performance references are recommended when gauging self-efficacy for novel tasks (Bandura, 1993, 1997), it would be interesting to investigate whether task self-efficacy and performance are affected differently following high and low personal (i.e., self-referenced) performance feedback when people are depleted or not.

Although the results from the present study were obtained under highly controlled and contrived laboratory conditions, they may have important implications for sport and exercise science researchers and practitioners. For example, at the beginning of an experimental session, training workout, or competition, when participants' self-control resources are fully intact, high feedback might be expected to lead to a "coasting" effect, whereas low feedback could increase performance. However, at the end of a physically, mentally, or emotionally demanding experimental session, game, or workout when resources are depleted, high feedback may help people overcome the negative effects of self-control depletion and give them the confidence to dig a little deeper to exert additional resources than they would otherwise. Conversely, caution should be taken when providing low feedback (e.g., in the attempt to "psych" someone up) when in a depleted state as the present findings suggest individuals are particularly sensitive to this type of feedback which could drastically reduce their self-efficacy and exercise performance.

In conclusion, the present study has provided the first evidence that normative performance feedback influences self-efficacy and physical endurance performance differently depending on the degree of self-control strength depletion. When people are not depleted of self-control strength, high feedback leads to lower self-efficacy and reduced performance whereas low feedback leads to higher self-efficacy and increased performance. However, when people are depleted of their self-control strength, high feedback leads to greater self-efficacy and better performance whereas low feedback leads to lower self-efficacy and worse performance.

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Table 1

Comparison of Age, Potential Covariates, and Manipulation Checks by Condition

	Control						Depletion					
	No Feedback		High Feedback		Low Feedback		No Feedback		High Feedback		Low Feedback	
	M (*SD*)		*M* (*SD*)		*M* (*SD*)		*M* (*SD*)		*M* (*SD*)		*M* (*SD*)	
Age	20.00	(1.84)	20.61	(2.60)	21.42	(2.74)	19.77	(5.59)	20.50	(6.12)	20.73	(2.63)
Potential covariates												
Brief SCS	43.27	(8.51)	43.07	(6.49)	43.00	(7.92)	42.93	(7.85)	42.57	(8.86)	45.20	(7.08)
NRS trial 1	3.92	(2.37)	4.20	(1.92)	4.36	(1.76)	4.05	(1.86)	3.99	(1.41)	4.71	(2.26)
BMIS pleasant	16.18	(12.18)	22.31	(11.50)	16.42	(14.52)	15.92	(16.10)	18.21	(14.80)	18.00	(13.43)
BMIS arousal	23.18	(7.22)	23.17	(6.85)	21.77	(4.87)	23.46	(5.82)	20.29	(5.53)	24.60	(7.17)
IMI pre-trial 1	6.29	(0.62)	5.92	(0.58)	6.13	(0.63)	6.12	(0.89)	5.96	(0.67)	6.44	(0.62)
IMI post-trial 1	6.35	(0.72)	6.29	(0.58)	6.40	(0.67)	6.32	(0.70)	6.23	(0.54)	6.48	(0.67)
IMI pre-trial 2	6.27	(0.88)	6.22	(0.58)	6.27	(0.57)	6.14	(0.75)	6.07	(0.72)	6.39	(0.71)
IMI post-trial 2	6.40	(0.66)	6.48	(0.44)	6.38	(0.62)	6.31	(0.73)	6.21	(0.77)	6.32	(0.71)
Manipulation checks												
Stroop trials	540.36	(85.00)	581.31	(123.02)	581.58	(123.24)	281.00	(44.73)	289.14	(44.43)	272.73	(60.00)
Stroop errors	0.81	(1.17)	0.31	(0.63)	0.50	(0.80)	6.77	(3.42)	8.93	(4.51)	9.13	(3.72)
RPME	3.00	(2.84)	2.40	(1.79)	2.72	(2.24)	7.38	(2.06)	5.93	(2.46)	7.13	(2.33)
Trial 1 RPE	8.55	(1.44)	8.61	(1.75)	8.42	(1.38)	8.69	(1.25)	8.14	(1.55)	8.73	(1.16)
Trial 2 RPE	8.41	(1.71)	9.35	(0.94)	8.70	(1.56)	8.77	(1.25)	8.32	(1.46)	8.73	(1.40)
NRS trial 2	3.94	(2.53)	6.54	(1.41)	2.30	(2.01)	3.50	(1.58)	6.02	(1.76)	2.45	(1.81)
FA scale	--	--	7.85	(2.08)	8.25	(1.96)	--	--	8.00	(1.62)	8.20	(1.97)

Note: *M* = mean, *SD* = standard deviation, SCS = self-control scale, NRS = normative rating scale, BMIS = brief mood introspection scale, IMI = intrinsic motivation inventory effort and importance subscale, RPME = ratings of perceived *mental* exertion, RPE = ratings of perceived *physical* exertion, FA = feedback awareness scale.

Table 2

Handgrip Endurance, Trial-to-Trial Change Scores, and Self-Efficacy scores by Condition

	Control			Depletion		
	No Feedback	High Feedback	Low Feedback	No Feedback	High Feedback	Low Feedback
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Trial 1 handgrip score (s)	72.55 (23.46)	97.84 (31.59)	75.33 (27.47)	99.54 (30.47)	94.00 (24.65)	89.13 (27.45)
Trial 2 handgrip score (s)	75.64 (16.49)	82.61 (22.70)	79.75 (24.09)	83.46 (24.04)	88.50 (23.52)	68.13 (22.80)
Trial 1 – Trial 2 Δ	3.09 (19.38)	-15.23 (17.42)	4.42 (14.53)	-16.08 (15.98)	-5.50 (14.20)	-21.00 (11.26)
Task self-efficacy	4.75 (1.74)	3.73 (2.02)	4.82 (1.02)	3.17 (1.18)	4.27 (1.17)	3.48 (1.69)

Note: s = seconds, *M* = mean, *SD* = standard deviation scale, Δ = trial-to-trial change.

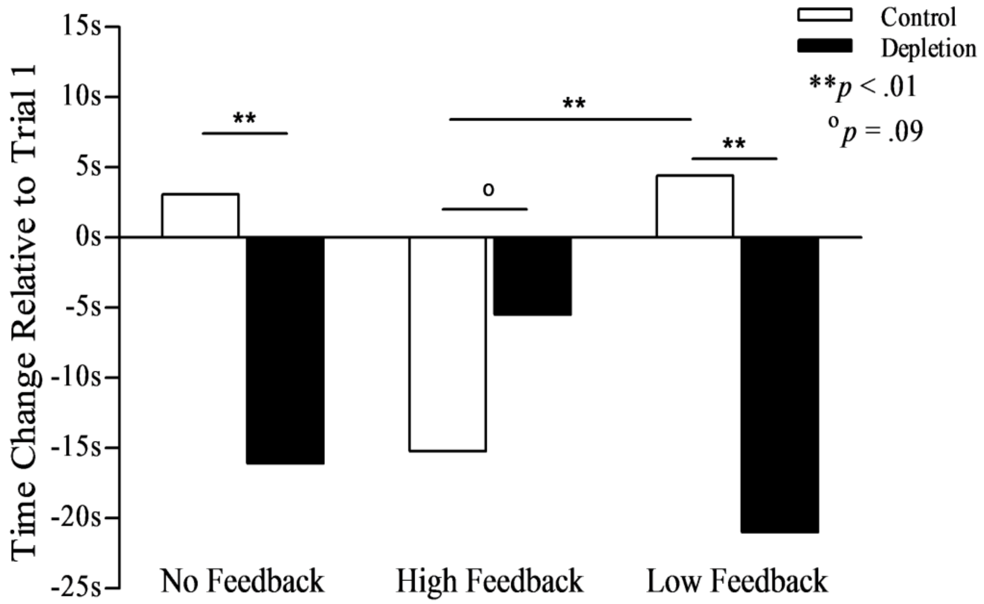

Figure 1a. Changes in time to failure from Trial 1 to Trial 2 by condition

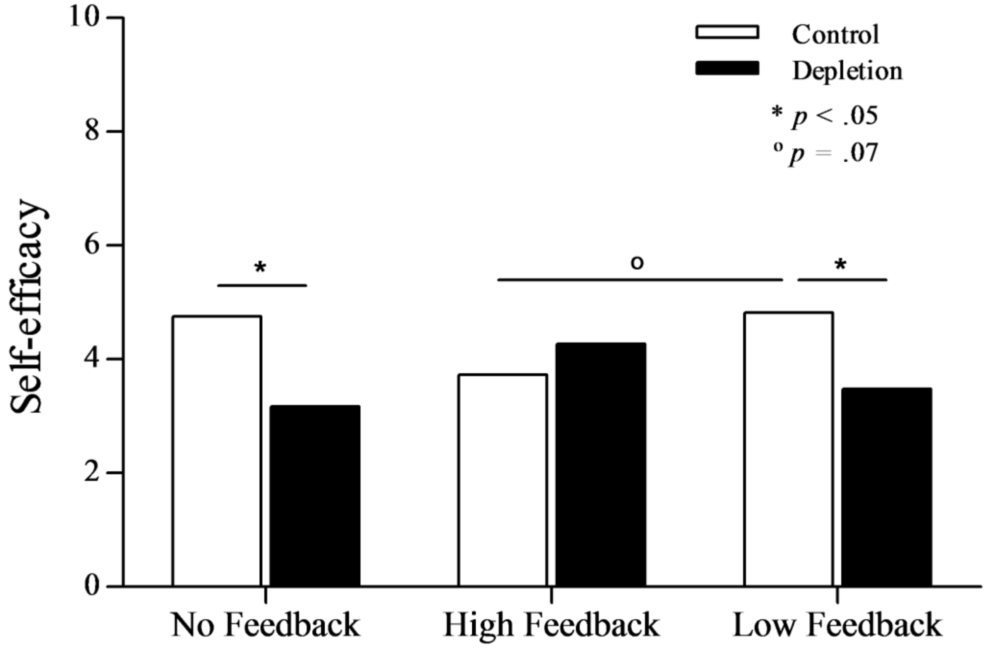

Figure 1b. Task self-efficacy for endurance Trial 2 (relative to Trial 1) by condition

CHAPTER 5:

GENERAL DISCUSSION

The overarching objective of this dissertation was to investigate the effects of self-control strength depletion on self-efficacy and physical exercise performance drawing from the strength model of self-control (Baumeister, 2014), self-efficacy theory (Bandura, 1997), and control theory (Carver & Scheier, 1998, 2011). Findings from Study 1 provide the first evidence that task self-efficacy is negatively affected following self-control depletion and also mediates the negative change that occurs in *physical* self-control performance. Results from Study 2 showed that increased subjective fatigue following self-control depletion is an antecedent to reduced self-efficacy and contributes to a serial mediation model explaining changes in physical performance. Study 3 extended studies 1 and 2 and provided the first evidence that normative performance feedback has differential effects on self-efficacy and physical endurance performance depending on the degree of self-control strength depletion one has experienced. The overall purpose of this chapter is to highlight the theoretical and practical contributions of this dissertation, address the limitations related to the research, and provide recommendations for future directions based on the current findings.

5.1 THEORETICAL IMPLICATIONS

Studies from this dissertation lend support to existing theory (Bandura, 1997) and help to illustrate an important role for self-efficacy within the strength model of self-control (Baumeister, 2014) as well as control theory (e.g. Carver & Scheier, 1998, 2011). Previous research assessing self-efficacy following self-control depletion concluded that self-efficacy was not associated with self-control strength (e.g., Finkel, Dalton, Campbell, Brunell, Scarbeck, & Chartrand, 2006; Wallace & Baumeister, 2002). However, in Study 1, participants reported a reduction in task self-efficacy following self-control depletion which mediated the negative change in physical endurance performance. It is critical to note that in previous studies assessing self-efficacy following self-control depletion, self-efficacy was operationalized in ways that did not correspond with Bandura's (1997) conceptual definition or recommendations for measurement (Bandura, 2006). The present findings addressed this limitation and in so doing provided a theory-based account for the negative effects of self-control depletion on subsequent task performance.

Study 2 also made important contributions to the strength model (Baumeister, 2014) by providing evidence that the exertion of self-control causes increased subjective fatigue and reduced self-efficacy to exert further self-control. Although previous research has reported increased subjective fatigue following self-control depletion (Hagger, Wood, Stiff, & Chatziarantis, 2010) subjective fatigue has characteristically been measured using single-item measures developed by the study authors. Study 2 addressed this limitation by assessing subjective (self-control) fatigue using a reliable and valid measure, the State Self-Control Capacity Scale (SSCCS), developed by Ciarocco, Twenge, Muraven and Tice (2004).

Beyond establishing the effects of self-control depletion on subjective fatigue, and task self-efficacy, Study 2 also represented the first attempt to investigate a theory-based causal process by which self-control depletion affects self-efficacy and self-control performance. Findings from sequential mediational analyses showed that self-control depletion affects task performance through subjective fatigue and self-efficacy. These findings are consistent with predictions of self-efficacy theory (Bandura, 1997) and again provide a logical causal mechanism explaining why self-efficacy and performance on a physically-demanding task are negatively affected by prior exertion of self-control on a task requiring only cognitive resources and no physical demands. Furthermore, findings provide support for contemporary theorizing by numerous authors (e.g., Inzlicht & Schmeichel, 2015; Kurzban, Duckworth, Kable, & Myers, 2013) that highlight motivational factors may also account for the negative performance change in self-control over repeated tasks as self-efficacy is a motivational perception that guides behaviour.

Study 3 was distinct from studies one and two of this dissertation inasmuch as it focused on relations between self-control strength depletion, self-efficacy, and self-control performance from the perspective of control theory (e.g., Carver & Scheier, 1998; 2011). As expected, findings supported control theory when self-control strength was not manipulated, showing that high feedback reduced subsequent self-controlled performance whereas low feedback increased subsequent performance. However, the reverse was seen when self-control strength resources were depleted with high feedback leading to better performance and low feedback leading to a worse performance. These findings provide the first evidence that self-control behaviour is affected differently following high and low feedback depending on the degree of self-control depletion.

The findings from Study 3 also showed a unique pattern of changes in self-efficacy suggesting that feedback information is interpreted differently following self-control depletion, potentially through attributional processing (e.g., Weiner, 1985). Findings supported Bandura's (1997) general theorizing in that high self-efficacy led to increases in performance and low self-efficacy led to decreases in performance supporting self-efficacy's role as a motivational perception that guides behaviour. However, it is interesting to note that when participants were not depleted of self-control strength, high feedback led to lower self-efficacy and low feedback led to higher self-efficacy whereas the reverse was observed following self-control strength depletion with high feedback leading to higher self-efficacy and low feedback leading to lower self-efficacy. Although the findings following self-control depletion are consistent with self-efficacy theory (Bandura, 1997) they paint a different picture altogether when self-control resources are intact. Nevertheless, these findings must be interpreted in light of the fact that most research involving self-efficacy has not involved tasks that require participants to fully exert themselves on successive tasks. Thus, further research is encouraged to disentangle self-efficacy's role within the control theory framework as well as following self-control strength manipulations over successive tasks.

Collectively, the studies in this dissertation provide support for theorizing by Bandura (1997) and highlight a central role for self-efficacy in the behavioural feedback loop of self-regulation proposed by control theorists (e.g., Carver & Scheier, 1998, 2011) and with regards to self-regulation failures that often occur within the operation phase of control theory (Baumeister, Heatherton, & Tice, 1994). Findings also align with motivational-cognitive accounts (Inzlicht & Schmeichel, 2015; Kurzban et al., 2013) of self-control showing that feedback and self-efficacy are important motivational-cognitive processes that affect behaviour differently based on the degree of self-control depletion. Accordingly, practical implications of this knowledge are important to share and the next section will discuss the practical implications from this dissertation as they pertain to sport and exercise behaviour and performance.

5.2 PRACTICAL IMPLICATIONS

In addition to the theoretical contributions outlined in the previous section, the findings of this dissertation provide a number of practical implications for understanding the self-regulation of behaviour including sport and exercise.
One of the key implications of findings from Study 1 is that task self-efficacy for a physically-demanding task can be acutely affected by performing other tasks that may, seemingly, have little to do with physical effort. For example, in many

sports athletes will spend a prolonged amount of time (e.g., 20-30 minutes) at the beginning of practice reviewing video footage of their prior performances and other teams' performances as well as when learning new techniques and strategies (e.g., zone defence). Immediately following these tasks involving high levels of information processing athletes are expected to apply these new strategies which often require complex decision making processes, motor control, and prolonged physical exertion. It is possible that athletes may be less confident in their abilities to execute these physical tasks, which may negatively influence the learning of new techniques and strategies (i.e., greater mistakes, prolonged learning). Thus, coaches and trainers should be considerate of the cognitive and emotional demands athletes engage in prior to physical task performance as they may reduce their athletes' self-efficacy and in turn physical performance.

Another practical implication for exercise science researchers and practitioners that stems from the findings of Study 2 relates to monitoring subjective fatigue states of their participants and exercisers. For example, it is common for research in exercise science to implement aerobic and resistance exercise training interventions to investigate various effects of training types and intensities on strength, muscle mass, and aerobic fitness (e.g., Gillen et al., 2014; Mitchell et la., 2012) as well as for treating many types of chronic diseases (e.g., Castaneda et al., 2002; Gibala, Little, MacDonald, & Hawley, 2012). However, in training studies participants are required to perform exercise tasks that undoubtedly require the exertion of self-control to overcome feelings of discomfort or fatigue in order to resist the temptation to quit and complete the exercise at the recommended intensities.

People regularly exert control over their behaviours, thoughts, and emotions over the course of a day and as the day wears on they are more likely to fail at self-regulation due to previous self-control exertion (Hofmann, Vohs, & Baumeister, 2012). As such, researchers and practitioners should anticipate that participants in training studies may arrive to the laboratory in various degrees of self-control fatigue states. Those who are more fatigued may not be confident in their abilities to perform the exercises at the recommended intensities or they may terminate the exercise tasks prematurely diminishing potential training effects. Thus, it may be an important consideration for exercise science researchers and practitioners to assess subjective fatigue through the SSCCS prior to having their participants and athletes perform any exercises as high levels of subjective fatigue may indicate that self-efficacy to perform the exercise tasks is low and result in reduced exercise performance.

In addition, and elaborating on the example above, the type of feedback may be especially important for situations where participants and athletes are in a fatigued state prior to exercise. For instance, if a participant arrives to the lab for a training (or testing) session and their subjective (self-control) fatigue is higher than baseline levels high, feedback may be especially important to boost their self-efficacy to exert self-control over the upcoming exercises maximizing training effects. Conversely, if subjective fatigue ratings are lower than baseline low feedback may be required at the beginning of the training session to prevent any coasting effects as they are most likely to be conserving their resources for the end of the exercise session (Baumeister, 2014; Jones et al., 2013).

Findings from Study 3 also have important implications for practice. One implication pertains to the role of feedback in sport and exercise science research and practice. Coaches, trainers and other interventionists use feedback as a strategy to manipulate self-efficacy and performance of athletes and other performers (Ashford, Edmunds, & French, 2010; Samson & Solmon, 2011). However, the present findings suggest that the type of feedback provided may be important to consider in concert with the self-control state of the feedback recipient. That is, given that self-control strength may be depleted to varying degrees during exercise or training sessions, people performing repeated challenging exercises are likely to respond to feedback differently based on the degree of their self-control depletion. For example, at the beginning of an experimental session, training workout, or competition, when an individual's self-control resources are fully intact, high normative feedback (e.g., "*You are performing superior to others*") might lead to a "coasting" effect and a reduction in performance, whereas low feedback (e.g., "*You are performing worse than others"*) could increase performance. On the contrary, at the end of a physically, mentally, or emotionally demanding experimental session, game, or workout when self-control resources are depleted, high feedback may help individuals overcome the debilitating effects of self-control depletion and give them the confidence to dig a little deeper to exert additional self-control resources. However, it appears especially important that caution should be taken when providing low feedback (e.g., in the attempt to "psych" someone up) to individuals when they are in a depleted state as the present findings suggest this type of information could drastically reduce their self-efficacy and exercise performance.

Although the above examples pertain to sport and exercise performance, they may also be applicable to other laboratory settings when assessing self-regulation and self-control processes. For instance, administering the SSCCS at the beginning of an experimental session may be an important consideration, when assessing the effects of self-control strength depletion on performance, to control for baseline levels of subjective fatigue. Indeed, research has shown that baseline scores on the SSCCS are predictive of poorer subsequent self-control task performance (Ciarocco et al., 2004, Study 5), which may be also mediated through participants' reduced self-efficacy to exert self-control.

Emerging research in sport and exercise science is supporting the notion that physical endurance performance is dictated by psychological constructs rather than physiological factors (e.g., Marcora & Staiano, 2010; Noakes, 2012). For instance, research examining the effects of self-regulatory fatigue (also represented as mental fatigue) on endurance exercise performance has shown that prolonged mental exertion leads to increased ratings of subjective fatigue, increased ratings of perceived effort during task performance, and a decrease in task performance (e.g., Marcora, Staiano, & Manning, 2009; MacMahon, Schucker, Hagemann, & Strauss, 2014; Pageaux, Lepers, Dietz, & Marcora, 2014; Pageaux, Marcora, Rozand, & Lepers, 2015). Importantly, in these studies and others, decreases in physical performance could not be attributed to changes in physiological variables (e.g., cardiovascular, respiratory, metabolic, or neuromuscular functioning) or psychological variables (e.g., motivation, mood/affect, or attentional focus) that are known to affect exercise performance. These findings led researchers to conclude that, following prolonged mental exertion, the increased perceptions of fatigue, and in some cases increased perceptions of effort during exercise, are the driving factors accounting for reductions in task performance. However, it is interesting to note that self-efficacy was not assessed in any of the studies examining the effects of self-regulatory fatigue on potential physiological and psychological mediators for reduced endurance performance.

5.3 LIMITATIONS AND FUTURE DIRECTIONS

This dissertation has shed light on the important role that self-efficacy plays within control theory and the strength model of self-control as well as how self-efficacy can be manipulated through bogus normative feedback to overcome the negative effects of self-control depletion. However, it is important to address some key limitations. One limitation relates to the fact that while the findings of the studies were obtained in highly controlled laboratory settings utilizing a cognitive self-control task (i.e., Stroop task) that is well-suited for laboratory settings to deplete self-control strength, further research is encouraged to incorporate self-control manipulations that mimic common tasks that arise in naturalistic sport and exercise contexts. Recent research has shown that when participants are required to regulate their emotions (e.g., Wagstaff, 2014), manage distractions (e.g. Englert, Bertrams, Furley, & Oudejans, 2015), and cope with anxiety (e.g., Englert, Zwemmer, Bertrams, & Oudejans, 2015), they show impaired performance on sport and exercise tasks including endurance cycling, basketball free throw shooting, and dart throwing accuracy. Nevertheless, future research is needed to examine the effects of self-control depletion on a range of tasks in sport and exercise domains (e.g., resistance exercise) utilizing manipulations of cognitive or emotional self-control that may be more generalizable to sport and exercise performance contexts such as those used in the studies above.

Another limitation is that all of the participants in the studies comprising this dissertation were considered relatively inactive as they engaged in less than the public health recommendations for physical activity (<150 min of moderate-vigorous physical activity per week (MVPA)) (Tremblay et al., 2011) and findings may not generalize to individuals who are highly trained such as competitive athletes. Although several studies have shown that trained individuals and competitive athletes also experience negative effects of self-control depletion (Dorris, Power, & Kenefick, 2012; Wagstaff, 2014), future research is needed to investigate if self-control depletion and performance feedback produce similar effects on task self-efficacy and exercise performance among active or trained sport participants.

The feedback manipulation used in Study 3 pertained to normative performance standards (i.e., a comparison to other study participants) rather than personal performance standards (i.e., a comparison to oneself). This characteristic of the feedback may limit the generalizability of the effects of self-control depletion and feedback on self-efficacy and physical endurance performance. Although normative performance references are recommended when gauging self-efficacy for novel tasks (Bandura, 1993, 1997), such as laboratory-based tasks, it would be interesting to investigate whether task self-efficacy and performance are affected differently following high and low personal (i.e., self-referenced) performance feedback when people are depleted or not as well as if these effects differ among inactive and active sport performers.

The findings are also limited to the measurement of self-efficacy for tasks with which participants had previous exposure (i.e., isometric handgrip and resistance exercise). Although self-efficacy was assessed in a manner consistent with Bandura’s recommendations for measurement (Bandura, 2006) it is possible that subjective fatigue may lead to decreases in self-efficacy to perform any task that requires self-control. That is, the effect of subjective fatigue on task self-efficacy (and performance) may be mediated by a change in overall (or general) self-efficacy to exert self-control, in general. Such a construct should be conceptually developed and validated using a battery of tests requiring self-control to see if self-control depletion leads to an overall reduction in self-efficacy for self-control.

The reduction in overall self-efficacy to exert self-control brought on by increased subjective (self-control) fatigue may be particularly important for understanding adaptive health behaviours and may explain why in certain circumstances these behaviours are simply not performed or are cut short. For example, reduced self-efficacy to exert self-control following extensive self-control demands during the workday may explain why someone decides to skip their planned exercise session, is unable to engage in the exercises at the desired intensities, or prematurely ends the workout. Reduced self-efficacy to exert self-control following emotional and cognitive self-control demands may also explain why a basketball player decides to pass instead of shoot a jump shot that would be considered relatively easy to make when self-control resources are intact. Similarly, reduced self-efficacy to exert self-control may explain why a long distance runner, who has managed to stay just steps behind the leader for the majority of the race, decides not to go for that final push when the leader starts to pull away. Studies that will allow for greater understanding of both generalized and specific forms of self-efficacy for self-control following self-control depletion will be important undertakings for future research in sport and exercise science.

A further caveat to the present findings is that although Study 2’s findings indicated increased levels of subjective fatigue following self-control depletion, other studies have not found increases in subjective fatigue (e.g., Finkel et al., 2006, Studies 1 and 2; Pageaux et al., 2014). It is possible the manipulations used in those studies did not adequately deplete self-control. However, it is also possible that experiencing subjective fatigue is not a necessary condition leading to changes in self-control performance. Given there has been little research devoted to exploring mechanisms by which self-control failures may occur, other mechanistic pathways explaining these effects are likely to be discovered and future research along these lines is recommended.

It is also important to acknowledge that subjective fatigue is only one antecedent of self-efficacy and even though increased subjective fatigue may lead to reductions in self-efficacy there may be many ways to boost self-efficacy in a similar manner in which positive (high) normative performance feedback increased self-efficacy in Study 3. As noted in the general introduction chapter, self-efficacy theory (Bandura, 1997) proposes numerous determinants of self-efficacy which may play important roles in altering responses to self-control depletion. For instance, previous research has shown that systematically practicing self-control handgrip exercises for two weeks led to increased endurance cycling performance (Bray, Graham, & Saville, 2015). Although repeated exposure to exerting self-control may have increased self-control strength, the mastery experience gained through practice also should have increased participants' overall self-efficacy for exerting self-control. Future research is encouraged to investigate changes in self-efficacy for self-control that may occur from self-control training.

As previously discussed, research has shown that increasing positive affect (Tice, Baumeister, Shmueli, & Muraven, 2007) can counteract the effects of prior depletion and lead to improved self-control task performance. Affective states are also determinants of self-efficacy (Bandura, 1997). Thus, it is possible that increased positive affect increased self-efficacy which in turn led to increased task performance. Indeed, many of the procedures and effects that have been found to modify the self-control depletion – performance relationship can be linked to determinants of self-efficacy. Future research is needed to build on the present research and more thoroughly investigate the role of self-efficacy in explaining self-control.

Furthermore, emerging evidence suggests relation-inferred self-efficacy (RISE) (Lent & Lopez, 2002) is an important source of personal self-efficacy that arises through the appraisal of competence-related feedback. RISE refers to an individual’s (person A) perceptions about what another person (or others) (person B) believes about their (person A’s) abilities. Research in sport and exercise settings has shown that youth sport participants (Saville & Bray, 2015; Saville, Bray, Martin Ginis, Cairney, Marinoff-Shupe, & Pettit, 2014), adolescent sport performers (Jackson, Myers, Taylor, & Beauchamp, 2012) and elite athletes (Jackson & Beauchamp, 2010; Jackson, Knapp, & Beauchamp, 2009) draw upon RISE perceptions to influence their own self-efficacy beliefs. Thus, an interesting avenue for future research is to investigate whether RISE manipulations could increase self-efficacy following self-control depletion and enhance subsequent self-controlled exercise performance in a similar fashion as other sources of self-efficacy discussed above.

Collectively, findings suggest that targeting the antecedents of self-efficacy may be important for future research endeavours to boost self-efficacy to help people overcome the negative effects associated with self-control depletion. In sport and exercise settings, athletes and exercisers are undoubtedly depleting self-control resources over prolonged periods such as over the course of a grueling tournament (e.g., regulating attention from distracting fans, managing negative emotions and anxiety) and throughout a long race (e.g., overcoming the increasing levels of pain, fatigue, and doubt). In situations like these, understanding ways to boost self-efficacy may be particularly important and could potentially explain why the best sport performers are able to achieve great feats over and over again despite being depleted of self-control resources. Yet, it remains unclear what strategies top athletes are performing to avoid self-control failures when they are in a depleted state. Are they cognizant of their overall self-efficacy to exert self-control which is indicated by their subjective fatigue state? If they sense reduced self-efficacy for self-control do they engage in acts such as positive imagery of success (i.e., mastery experiences) and positive self-talk (i.e., verbal persuasion) to give their selves a confidence boost in order to dig a little deeper? Thus, although findings made important theoretical and practical contributions to existing research on self-control, there are several questions that remain unanswered.

5.4 CONCLUSIONS

The research findings from this dissertation provide support for theorizing by Bandura (1997) insofar as self-efficacy is a motivational perception that guides self-controlled behaviour. This dissertation has also made important theoretical advancements highlighting self-efficacy's role in the behavioural feedback loop of self-regulation proposed by control theorists (e.g., Carver & Scheier, 1998, 2011) and within the self-control depletion – performance relationship proposed by the strength model of self-control (Baumeister, 2014). Findings support recent challenges to the strength model suggesting that self-control failures following self-control depletion are attributable to motivational-cognitive processes (Inzlicht & Schmeichel, 2015; Kurzban et al., 2013) involving self-efficacy and the interpretation of feedback.

Several adaptive health behaviours are highly dependent upon self-regulation and self-control processes including sport and exercise behaviours (e.g., de Ridder, Lensvelt-Mulders, Finkenhauser, Stok, & Baumeister, 2012; Hall & Fong, 2015; Michie, Abraham, Whittington, McAteer, & Gupta, 2009). Overall, findings suggest that self-efficacy can positively and negatively affect self-controlled behaviour depending on the state of self-control of the individual. Self-efficacy may be particularly important to target following the exertion of self-control as individuals can overcome self-control depletion when self-efficacy is boosted through feedback. Thus, findings from this dissertation highlight that the exertion of self-control leads to various dynamic psychophysiological responses that may be best understood by integrating several theoretical perspectives of self-regulation and self-control.

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APPENDIX A: STUDY 1 MATERIALS

Appendix A.1:
Task Self-Efficacy Scale

Compared to how long I went last time I am confident that I can hold on for:

Performance Rating	**Yes/No (Y or N)**	**Strength 0-10**
A) 25% as long		
B) 50% as long (half the time)		
C) 75% as long		
D) 100% as long (the same amount)		
E) 125% as long		
F) 150% as long		
G) 175% as long		
H) 200% as long (double the amount)		

Appendix A.2
Ratings of Perceived Physical Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix A.3
Ratings of Perceived Mental Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix A.4
Brief Self-Control Scale

SCS Scale

Please answer the following items as they apply to you. There are no right or wrong answers. Please choose a number (1 – 5) that best represents what you believe to be true about yourself for each question. Use the following scale to refer to how much each question is true about you.

1	**2**	**3**	**4**	**5**
Not at all like me		**Sometimes like me**		**Very Much like me**

1. I have a hard time breaking bad habits. _____

2. I am lazy. _____

3. I say inappropriate things. _____

4. I do certain things that are bad for me, if they are fun. _____

5. I refuse things that are bad for me. _____

6. I wish I had more self-discipline. _____

7. People would say that I have iron self-discipline. _____

8. Pleasure and fun sometimes keep me from getting work done. _____

9. I have trouble concentrating. _____

10. I am able to work effectively toward long-term goals. _____

11. Sometimes I can’t stop myself from doing something, even if I know it’s wrong. ____

12. I often act without thinking through all the alternatives. _____

13. I am good at resisting temptation. _____

Appendix A.5
New General-Self-Efficacy Scale

Please use the scale below to answer each of the following statements:

1	**2**	**3**	**4**	**5**
Strongly Disagree				**Strongly Agree**

1. I will be able to achieve most of the goals that I have set for myself. ______

2. When facing difficult tasks, I am certain that I will accomplish them. ______

3. In general, I think that I can obtain outcomes that are important to me. ______

4. I believe I can succeed at most any endeavor to which I set my mind. ______

5. I will be able to successfully overcome many challenges. ______

6. I am confident that I can perform effectively on many different tasks. ______

7. Compared to other people, I can do most tasks very well. ______

8. Even when things are tough, I can perform quite well. ______

Appendix A.6
Task Motivation Scale

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Not at all motivated		Weak motivation			Moderate motivation			Strong motivation		Extremely motivated

Instructions

Motivation refers to the how much you want to keep going (persistence) and the extent to which you want to push yourself to work harder (effort).

Appendix A.7
Intrinsic Motivation Inventory Effort and Importance Subscale

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For handgrip squeezing <u>task I am about to do</u>:

1. I am going to put a lot of effort into this. ______
2. I am not going to try very hard to do well at this activity. ______
3. I am going to try very hard on this activity. ______
4. It is important to me to do well at this task. ______
5. I am not going to put much energy into this. ______

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For the handgrip squeezing <u>task I just completed</u>:

1. I put a lot of effort into that task. ______
2. I didn’t try very hard to do well at that task. ______
3. I tried very hard on that task. ______
4. It was important to me to do well at that task. ______
5. I didn’t put much energy into that task. ______

6.

Appendix A.8
Perceived Effort and Difficulty Scales

Please use the scales below to answer each of the following statements by circling the corresponding number:

"How much effort do you think the endurance handgrip task will require?"

No Effort **Moderate Effort** **Maximum Effort**

0 1 2 3 4 5 6 7 8 9 10

"How difficult do you think the endurance handgrip task will be?"

Not Difficult **Somewhat Difficult** **Very Difficult**

0 1 2 3 4 5 6 7 8 9 10

Please use the scales below to answer each of the following statements by circling the corresponding number:

"How much effort did the endurance handgrip task require?"

No Effort **Moderate Effort** **Maximum Effort**

0 1 2 3 4 5 6 7 8 9 10

"How difficult was the endurance handgrip task?"

Not Difficult **Somewhat Difficult** **Very Difficult**

0 1 2 3 4 5 6 7 8 9 10

Appendix A.9
Activation-Deactivation Check List-Short Form

Each of the words below describes feelings or mood. Please use the rating scale below and circle the response on the scale below that indicates your feelings ***at this moment.***

	1	2	3	4
	Definitely Do <u>Not</u> Feel			**Definitely Feel**
1. Active	**1**	**2**	**3**	**4**
2. Placid	**1**	**2**	**3**	**4**
3. Sleepy	**1**	**2**	**3**	**4**
4. Jittery	**1**	**2**	**3**	**4**
5. Energetic	**1**	**2**	**3**	**4**
6. Intense	**1**	**2**	**3**	**4**
7. Calm	**1**	**2**	**3**	**4**
8. Tired	**1**	**2**	**3**	**4**
9. Vigorous	**1**	**2**	**3**	**4**
10. At-rest	**1**	**2**	**3**	**4**
11. Drowsy	**1**	**2**	**3**	**4**
12. Fearful	**1**	**2**	**3**	**4**
13. Lively	**1**	**2**	**3**	**4**
14. Still	**1**	**2**	**3**	**4**
15. Wide-awake	**1**	**2**	**3**	**4**
16. Clutched-up	**1**	**2**	**3**	**4**
17. Quiet	**1**	**2**	**3**	**4**
18. Full-of-pep	**1**	**2**	**3**	**4**
19. Tense	**1**	**2**	**3**	**4**
20. Wakeful	**1**	**2**	**3**	**4**

APPENDIX B: STUDY 2 MATERIALS

Appendix B.1
Godin Leisure-Time Exercise Questionnaire

EXERCISE SCREENING QUESTIONNAIRE

Over the past 6 months, how many times **on average** have you done the following kinds of exercise for 30 minutes or more during your **free time** in a week? Free time is your leisure time, it represents the time in which you freely chose to do things, not because you have to do them for some other activity or task.

Times per week

STRENUOUS EXERCISE (your heart beats rapidly): __________
(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling, skating)

MODERATE EXERCISE (not exhausting): __________
(e.g., fast walking, weight-training, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, dancing)

MILD EXERCISE (minimal effort): __________
(e.g., yoga, archery, fishing, bowling, horseshoes, golf, snow-mobiling, easy walking)

Appendix B.2
Physical Activity Readiness Questionnaire

You are eligible for this study if you answer **NO** to the questions below

1. Have a medical condition that requires you to avoid strenuous exercise?

2. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

3. Do you feel pain in your chest when you do physical activity?

4. In the past month, have you had chest pain when you were not doing physical activity?

5. Do you lose balance because of dizziness or do you lose consciousness?

6. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

7. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

8. Do you know of any other reason why you should not do physical activity?

9. Are you colour blind?

Appendix B.3
Task Self-Efficacy Scale

Compared to how many repetitions I completed last time on bench press, I am confident that I can complete:

Performance Rating	**Yes/No (Y or N)**	**Strength 0-10**
A) 25% as many		
B) 50% as many (half the amount)		
C) 75% as many		
D) 100% as many (the same amount)		
E) 125% as many		
F) 150% as many		
G) 175% as many		
H) 200% as many (double the amount)		

Compared to how many repetitions I completed last time on leg extension, I am confident that I can complete:

Performance Rating	**Yes/No (Y or N)**	**Strength 0-10**
A) 25% as many		
B) 50% as many (half the amount)		
C) 75% as many		
D) 100% as many (the same amount)		
E) 125% as many		
F) 150% as many		
G) 175% as many		
H) 200% as many (double the amount)		

Appendix B.4

Ratings of Perceived Physical Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix B.5

Ratings of Perceived Mental Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix B.6

Sate Self-Control Capacity Scale

For each of the following statements, please indicate how true it is for you, using the following scale:

1	2	3	4	5	6	7
Not true						**Very true**

1. I need something pleasant to make me feel better. ______
2. I feel drained. ______
3. If I were tempted by something right now, it would be very difficult to resist. ______
4. I would want to quit any difficult task I was given. ______
5. I feel calm and rational. ______
6. I can’t absorb any information. ______
7. I feel lazy. ______
8. I feel sharp and focused. ______
9. I want to give up. ______
10. I feel like my will power is gone. ______

Appendix B.7
Brief Self-Control Scale

SCS Scale

Please answer the following items as they apply to you. There are no right or wrong answers. Please choose a number (1 – 5) that best represents what you believe to be true about yourself for each question. Use the following scale to refer to how much each question is true about you.

1	**2**	**3**	**4**	**5**
Not at all like me		**Sometimes like me**		**Very Much like me**

1. I have a hard time breaking bad habits. _____

2. I am lazy. _____

3. I say inappropriate things. _____

4. I do certain things that are bad for me, if they are fun. _____

5. I refuse things that are bad for me. _____

6. I wish I had more self-discipline. _____

7. People would say that I have iron self-discipline. _____

8. Pleasure and fun sometimes keep me from getting work done. _____

9. I have trouble concentrating. _____

10. I am able to work effectively toward long-term goals. _____

11. Sometimes I can’t stop myself from doing something, even if I know it’s wrong. ____

12. I often act without thinking through all the alternatives. _____

13. I am good at resisting temptation. _____

Appendix B.8

New General Self-Efficacy Scale

Please use the scale below to answer each of the following statements:

1	**2**	**3**	**4**	**5**
Strongly Disagree				**Strongly Agree**

1. I will be able to achieve most of the goals that I have set for myself. ______

2. When facing difficult tasks, I am certain that I will accomplish them. ______

3. In general, I think that I can obtain outcomes that are important to me. ______

4. I believe I can succeed at most any endeavor to which I set my mind. ______

5. I will be able to successfully overcome many challenges. ______

6. I am confident that I can perform effectively on many different tasks. ______

7. Compared to other people, I can do most tasks very well. ______

8. Even when things are tough, I can perform quite well. ______

Appendix B.9

Intrinsic Motivation Inventory Effort and Importance Subscale

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For the exercise tasks I am about to do:

1. I am going to put a lot of effort into this. ______
2. I am not going to try very hard to do well at this activity. ______
3. I am going to try very hard on this activity. ______
4. It is important to me to do well at this task. ______
5. I am not going to put much energy into this. ______

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For the exercise tasks I just completed:

1. I put a lot of effort into that task. ______
2. I didn’t try very hard to do well at that task. ______
3. I tried very hard on that task. ______
4. It was important to me to do well at that task. ______
5. I didn’t put much energy into that task. ______

Appendix B.10
Brief Mood Introspection Scale

The next items are statements about your mood. Please circle the response on the scale below that indicates how well each adjective describes your present mood.

	1	2	3	4	5	6	7
	Definitely Do Not Feel						**Definitely Do Feel**
1. Lively	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Peppy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Active	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Happy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Loving	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Caring	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Drowsy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. Tired	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9. Nervous	**1**	**2**	**3**	**4**	**5**	**6**	**7**
10. Calm	**1**	**2**	**3**	**4**	**5**	**6**	**7**
11. Gloomy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
12. Fed up	**1**	**2**	**3**	**4**	**5**	**6**	**7**
13. Sad	**1**	**2**	**3**	**4**	**5**	**6**	**7**
14. Jittery	**1**	**2**	**3**	**4**	**5**	**6**	**7**
15. Grouchy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
16. Content	**1**	**2**	**3**	**4**	**5**	**6**	**7**

APPENDIX C: STUDY 3 MATERIALS

Appendix C.1
Task Self-Efficacy Scale

Compared to how long I went last time I am confident that I can hold on for:

Performance Rating	Yes/No (Y or N)	Strength 0-10
A) 25% as long		
B) 50% as long (half the time)		
C) 75% as long		
D) 100% as long (the same amount)		
E) 125% as long		
F) 150% as long		
G) 175% as long		
H) 200% as long (double the amount)		

Appendix C.2
Ratings of Perceived Physical Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix C.3
Ratings of Perceived Mental Exertion Scale

0	Nothing at all
0.3	
0.5	Extremely weak
1	Very weak
1.5	
2	Weak
2.5	
3	Moderate
4	
5	Strong
6	
7	Very Strong
8	
9	
10	Absolute Maximum

Appendix C.4
Normative Self-Efficacy Rating Scale

Compared to other participants in this study, I am confident that I can squeeze the handgrip for longer than:

Performance Rating	**Yes/No (Y or N)**	**Strength 0-10**
A) 10% of the participants		
B) 20% of the participants		
C) 30% of the participants		
D) 40% of the participants		
E) 50% of the participants		
F) 60% of the participants		
G) 70% of the participants		
H) 80% of the participants		
I) 90% of the participants		
J) 100% of the participants		

Appendix C.5
Feedback Awareness Scale

"I believed what the experimenter told me about my performance after the 1st endurance trial"

1 2 3 4 5 6 7 8 9 10

Did not believe **Believed**

Appendix C.6
Brief Self-Control Scale

SCS Scale

Please answer the following items as they apply to you. There are no right or wrong answers. Please choose a number (1 – 5) that best represents what you believe to be true about yourself for each question. Use the following scale to refer to how much each question is true about you.

1	2	3	4	5
Not at all like me		**Sometimes like me**		**Very Much like me**

1. I have a hard time breaking bad habits. _____

2. I am lazy. _____

3. I say inappropriate things. _____

4. I do certain things that are bad for me, if they are fun. _____

5. I refuse things that are bad for me. _____

6. I wish I had more self-discipline. _____

7. People would say that I have iron self-discipline. _____

8. Pleasure and fun sometimes keep me from getting work done. _____

9. I have trouble concentrating. _____

10. I am able to work effectively toward long-term goals. _____

11. Sometimes I can’t stop myself from doing something, even if I know it’s wrong. ____

12. I often act without thinking through all the alternatives. _____

13. I am good at resisting temptation. _____

Appendix C.7
Brief Mood Introspection Scale

The next items are statements about your mood. Please circle the response on the scale below that indicates how well each adjective describes your present mood.

	1	**2**	**3**	**4**	**5**	**6**	**7**
	Definitely Do Not Feel						**Definitely Do Feel**
1. Lively	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Peppy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Active	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Happy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Loving	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Caring	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Drowsy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. Tired	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9. Nervous	**1**	**2**	**3**	**4**	**5**	**6**	**7**
10. Calm	**1**	**2**	**3**	**4**	**5**	**6**	**7**
11. Gloomy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
12. Fed up	**1**	**2**	**3**	**4**	**5**	**6**	**7**
13. Sad	**1**	**2**	**3**	**4**	**5**	**6**	**7**
14. Jittery	**1**	**2**	**3**	**4**	**5**	**6**	**7**
15. Grouchy	**1**	**2**	**3**	**4**	**5**	**6**	**7**
16. Content	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Appendix C.8
Intrinsic Motivation Inventory Effort and Importance Subscale

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For handgrip squeezing <u>task I am about to do</u>:

1. I am going to put a lot of effort into this. ______
2. I am not going to try very hard to do well at this activity. ______
3. I am going to try very hard on this activity. ______
4. It is important to me to do well at this task. ______
5. I am not going to put much energy into this. ______

For each of the following statements, please indicate how true it is for you, using the following scale:

1	**2**	**3**	**4**	**5**	**6**	**7**
Not at all true			**Somewhat true**			**Very true**

For the handgrip squeezing <u>task I just completed</u>:

1. I put a lot of effort into that task. ______
2. I didn’t try very hard to do well at that task. ______
3. I tried very hard on that task. ______
4. It was important to me to do well at that task. ______
5. I didn’t put much energy into that task. ______

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Appendix D.1

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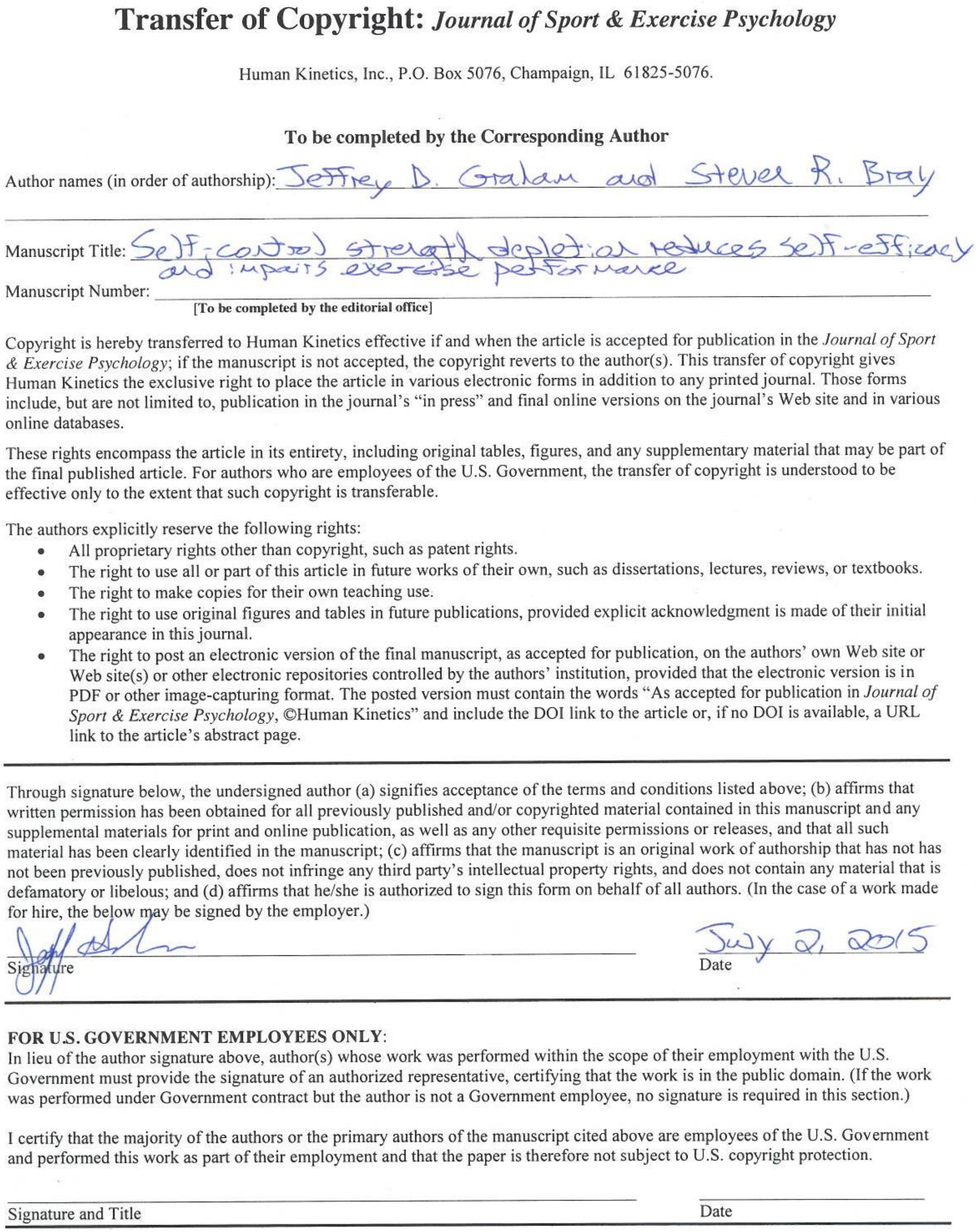

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