EFFECTS OF CONSTRUAL LEVELS AND SELF-CONTROL STRENGTH IN EFFORTFUL CYCLING EXERCISE

EFFECTS OF CONSTRUAL LEVELS AND SELF-CONTROL STRENGTH IN EFFORTFUL CYCLING EXERCISE

By

ALEXANDER TRAN, HONS. BSC.

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree Master of Science

McMaster University

MASTER OF SCIENCE (2013)	McMaster University
Kinesiology	Hamilton, Ontario

TITLE: Effects of construal levels and self-control strength in effortful cycling exercise

AUTHOR: Alexander Tran, Hons. Bsc. (McMaster University)

SUPERVISOR: Dr. S. R. Bray

NUMBER OF PAGES: vi, 66

Abstract

Self control is affected by self-regulatory strength depletion (Hagger et al., 2010) as well as construal-level mindset (Fujita et al., 2006). However, two conflicting perspectives have emerged predicting differential interactive effects of construals and depletion. The purpose of the present study was to investigate the independent and interactive effects of construal levels and self-control strength in an effortful cycling exercise task. Using a randomized 2 X 2 factorial design, undergraduate participants (N = 67, n = 34 women) completed a baseline cycling task, followed by a self-control depletion manipulation (Stroop task vs. quiet rest; Wallace & Baumeister, 2002), a construal-level manipulation (category vs. exemplar naming task; Fujita et al., 2006), and then a 10-minute strenuous cycling test trial. The results showed no main effects for either self-control strength depletion or construal level ($p > .20$). However there was a near-significant interaction effect ($p = .07$) indicating the depleted group outperformed the non-depleted group in the low-construal condition, whereas the opposite effect occurred in the high-construal condition. The results provide novel insights of the effects of self-control strength depletion and construal mindsets on exercise performance and implications for the design of construal level and self-control depletion research.

Acknowledgements

First of all I would like to thank Dr. Steve Bray for your guidance, encouragement, and most importantly patience throughout the entirety of this project. You have found the perfect balance of freedom and meticulous supervision during my thesis and discovered the exact research niche for my interests. The style with which you carry out your supervision will not soon be forgotten and you are a role model for me in more ways than one.

I also would like to thank my co-supervisor and committee member Dr. Kathleen Martin Ginis for whom this thesis would never have happened. It was you who suggested that I complete an independent research project, and ultimately a Master's thesis with Dr. Bray. You are an incredible academic role model and have helped me solidify my interests in the field of research, thank you.

Also I would like to thank my mother, her perseverance through hardships and dedication to family will forever be an inspiration for my efforts. In addition, my brothers Andrew and Aaron have always shown me love and support through the stressful times of this project.

I would like to thank my lab- Jeff, Paul, Jenn, Jessie, Becky, Denver, Matt, Desi, believe it or not you have all had an influential impact on the completion of my thesis. You will all hold special moments in my life and I look forward to seeing you all in the near future.

Finally Megan, without your calming words and consistent encouragement, I would not be where I am today. You are, and always will be my other half.

Table of Contents

List of Tables and Figures

INTRODUCTION

Some animals are slaves to their immediate impulses; however, in humans, evolution has created the frontal lobe, a structure devoted to higher-level thinking and executive function. The term *executive function* relates to the ability to regulate, manage and control cognitive processes such as attention, inhibition and planning. Without executive function, the pursuit of tasks related to distal goals is impossible (Burgess, 1997). Many non-human species are stimulus-response beings that are unable to override their innate impulses in order to strive for a higher goal. In contrast, humans have the capability to control impulses and delay gratification and therefore are able to engage in acts of self regulation. Among the most important enactments of self regulation in modern society are health behaviours such as maintaining a nutritious diet and being physically active.

Unfortunately, one of the most difficult issues relating to health behaviours is adherence. For instance, only 50% of those who initiate a program of physical activity are able to maintain the behaviour for longer than 6 months (e.g., Dishman, 1988). Changing one's behaviour and sustaining those changes over time requires self-regulatory resources. These resources are necessary to carry out the behaviour and to override temptations to lapse back into one's habitual routines. People's struggles with adherence may be due to the fact that self regulation is dependent upon an internal resource, which, similar to a muscle, is limited in its strength and vulnerable to fatigue. After use, self-regulation strength becomes weakened and people are less likely to inhibit responses, resist temptations, and muster effort for future acts requiring self regulation such as exercising (Baumeister, Tice & Heatherton, 1994).

One example of a behaviour for which self-regulatory resources are necessary is maintaining levels of daily physical activity. Research shows that approximately 85% of

Canadians are not meeting the recommended levels of physical activity (Colley, Garriguet, Janssen, Craig, Clarke & Tremblay, 2011). Modern society has created many devices that eliminate the need for physical activity such as; cars to drive to work, machines that operate to lift heavy objects, escalators or elevators that make the use of stairs obsolete etc. For many people, using work or labour-saving devices has become the normal or habitual behaviour. Changing those behaviours to engage in activities such as walking or cycling to work or taking the stairs rather than the elevator requires self regulation to over-ride one's usual tendencies. Throughout the day, exerting self control through various activities (e.g., regulating emotions and thoughts) depletes the self-regulation resource and it gradually becomes more difficult to control behaviours (Baumeister et al., 1994). As self-regulation resources become depleted, people may be less likely to engage in physical activities in place of, or in addition to, their usual routine of sedentary activities. Another potential contributor to failures of self regulation may be the saliency of immediate rewards compared to the more distal outcomes achieved through regulation of behaviour.

The relative proximity of behaviourally-contingent rewards or outcomes in relation to self regulation has been investigated from the perspective of people's mindsets or construals about the target behaviour (Trope & Liberman, 2003). For instance, when an individual adopts a narrowly-focused mindset, occupied with the many little nuances associated with executing a behaviour, there is a high demand on his/her attentional processes to maintain focus on those details. As a result of this intense narrow focus, attention is taken away from broad goals and potential rewards of the behaviour. Alternatively, when one is in a broader, more abstract, mindset s/he is thinking about general concepts and categories of the behaviour such as why the behaviour is being undertaken or the implications of executing the behaviour. By thinking abstractly, information about outcomes and goal of the current behaviours is more accessible.

People's construal levels have been described as being important to engaging in self-control behaviours (Fujita, 2008). According to Fujita, the impact of construal mindsets on self regulation can be illustrated when a dieter is faced with the temptation of a food item that violates the goal of his/her diet. When faced with this self-control conflict, a dieter in a high-construal mindset is better able to focus on the goals and abstract details of dieting (e.g., avoiding health risks, potential effects on physical appearance) and, thus, avoid consuming the tempting food. However, when a dieter is in a low-construal mindset his or her focus is more likely to be on concrete details of the behaviour (e.g., how to eat the cake and how it would taste) rather than the goals of the diet, s/he would be more likely to eat the cake and fail at self control.

Another example can be found in the exercise domain, where a runner may run an identical route under two differing mindsets and experience varying levels of successful self regulation. In one scenario, when the individual is occupied by thoughts of high-level details such as the abstract health benefits or feeling of achievement or relaxation as a result of the run, self regulation should be facilitated. In contrast, a situation where the runner is thinking about low-level detail such as his/her heart rate, shortness of breath or muscle fatigue, this mindset may lead to the temptation to quit and a failure of self regulation. Adopting a particular mindset, therefore, may have important implications for one's perceived effort and performance during the execution of self-regulated behaviour such as exercise (Fujita, 2008).

Although construal levels and self-control strength both attempt to account for failures of self regulation there is little evidence relating to how these constructs may complement or conflict in their effects during attempts at self control. The purpose of this study is to address this gap in the literature and investigate the implications of one's focus on details or goals (construals) at different levels of self-regulatory strength depletion.

LITERATURE REVIEW

Self-regulation of Behaviour

Self regulation refers to the ability to override or alter responses in order to bring a behaviour (or other states such as cognitions or emotions) in line with an ideal or goal (Baumeister, Vohs & Tice, 2007). Several perspectives on behavioural self regulation have been proposed (Baumeister et al., 1994), but in their analysis of the literature, Baumeister et al. (1994) identified two concepts or "ingredients" that are consistent across most theories of self-regulation: *standards* and *monitorin*g. *Standards* refer to goals or a personal state that individuals strive to achieve through execution of a given behaviour. Another important aspect of self regulation involves *monitoring* of behaviour. Monitoring of one's behavioural or internal states is vital, as ongoing comparisons must be made between the current state and the desired standard or goal. However, in addition to these two core ingredients, Baumeister, Bratlavsky, Muraven & Tice (1998) go on to identify a third "ingredient" that also contributes to successful self regulation: self-control strength.

The Strength Model of Self-control

Following up from their influential review of behavioural self regulation (Baumeister et al., 1994), Baumeister et al. (1998) proposed and tested the idea that controlling one's thoughts, emotions or behaviours is dependent on a type of internal energy or strength. According to their model, self-control strength can be conceptualized along the lines of 5 key assumptions (Muraven & Baumeister, 2000). The first assumption is that self-control strength is an integral component of executive control, that is, acts of volition and self control require strength.

Second, self-control strength is limited in capacity and, similar to working memory and attention, can only be used to override a finite number of responses at a time. Another key assumption is that self control is a global resource, and regardless of the sphere (emotional, cognitive or behavioural) all acts of self control consume some of one's resources available at a given time. A fourth assumption is that individuals contain a capacity for self-control strength, which determines their success at self control; those with depleted strength are more likely to succumb to a failure of self control. The final assumption of the model is that acts of self control expend the resource. Therefore, unlike attention and memory that may return to normal functioning levels when no longer being taxed, termination of self control does not return the resources to full capacity immediately, instead it requires rest or replenishment.

The self-control strength resource cannot be directly observed or monitored, thus Muraven and Baumeister (2000) proposed the analogy of a skeletal muscle to describe the function of self-control strength. The assumptions stated above lend themselves to the analogy of a muscle; as self control is fatigued with repeated or prolonged use it requires rest in order to restore its energy. In addition, self control is limited in its capacity but can be "exercised" to increase the resource stores or stamina (Oaten & Cheng, 2006). However, one fault of this analogy is that while a single muscle plays a role in a limited number of movements, self-control strength plays a role in all acts of self control across cognitive, emotional and behavioural realms.

Baumeister et al. (1998) and Muraven, Tice & Baumeister (1998) carried out the original studies investigating the strength model of self control. Those studies and the bulk of the literature published on the model, employ a sequential-task paradigm to illustrate the depletion of self-control strength (Hagger, Wood, Stiff, & Chatzisarantis, 2010; Muraven et al., 1998).

Typically studies involve execution of a sequence of two or three consecutive tasks, all of which require self-control strength. For instance, in a two-task experiment, one group of participants performs an initial task that expends self-control strength, while a control group performs an alternate form of the task that does not require self control, or quietly rests. Afterwards, both groups perform a different task that demands self-control strength and performance on this task is compared between the groups. A three-task design is used in some studies, primarily to control for individual differences that could affect performance of the dependent self-control task (e.g., handgrip squeezing endurance). In those studies, all participants perform an initial task that requires self-control strength to establish baseline performance scores for that task. Subsequently, one group then performs another self-control task, while the control group performs a task that does not further deplete self-control strength. All participants then complete a follow-up test of the initial task again and performance is assessed both between and within groups. The depletion effect typically manifests itself as a greater change between baseline and the follow-up task (decreased performance) compared to the control group.

A considerable variety of tasks have been used to investigate self-control depletion effects. For example, in a study by Muraven et al. (Study 2; 1998) participants were asked to suppress the thought of a white bear as an initial task of self-control strength depletion. The study consisted of 3 conditions, a thought suppression (self-control depletion) group, in addition to two controls, a no instruction thought group, and an express thought (told to think about a white bear as much as they could) group. Participants were then asked to perform an ostensibly unrelated task, attempting to solve unsolvable anagrams and persistence (a behavioural form of self control) was the measure of self control. The findings showed the group that suppressed thoughts of a white bear persisted for a shorter period of time trying to solve the anagrams (M =

563 sec) compared to both the "no instruction" control (M = 758 sec) and express thought control (M = 867 sec) groups ($p < .05$). These findings suggest that expending strength to suppress thoughts left individuals with less self-control strength to devote to over-riding the behavioural impulse to cease performance of the futile anagram task.

Muraven et al. (1998) conducted several other studies and found similar results for various self-control tasks. Regulating emotions while watching humorous or heart-wrenching video clips, controlling expressions of amusement, and physical stamina in a handgrip squeezing task were all found to cause, or be vulnerable to a depletion effect. Therefore, these behaviours have been used as indicators of self-control strength depletion or manipulations to deplete strength in the literature. Across those studies, results consistently showed that prior self-regulatory depletion predicted decreases in self-control performance on subsequent tasks (See Muraven et al., 1998; Studies 1 - 4).

Since the publication of the initial studies by Baumeister et al. (1998) and Muraven et al. (1998), the pre-post or sequential two-task research design has been used in well over 100 studies that were recently reviewed in a meta-analysis by Hagger et al. (2010). In their paper, the authors analyzed the average effect size of the depletion effect across 198 studies in addition to potential moderators and postulated extensions of the model. The meta-analysis extensively investigated the effects of the type of depleting task, type of dependent task, matching or mismatching of depletion and dependent tasks, among others. Overall, in support of the model, the depletion effect was consistent with a medium-to-large effect size (Cohen's d =0.62; Cohen, 1992) regardless of the type of self-control task (e.g., cognitive, emotional, behavioural), which provides evidence for the notion that self control is a global resource. Of importance to the present study, the effect size associated with controlling impulses (vs. choice and volition, social processing, cognitive processing) as the dependent task was the greatest (Cohen's $d = 0.71$, $N =$ 104 effects) and use of physical handgrip task as a dependent measure showed a medium-to-large effect size (Cohen's $d = 0.64$, $N = 18$ studies).

Although research on the strength model has largely employed laboratory-based tasks in the cognitive and emotional spheres, there has also been some evidence that the strength model can be applied to understanding health-related behaviours. For example, one narrative review by Hagger, Wood, Stiff and Chatzisarantis (2009) discussed research involving physically-demanding tasks and suggested the applicability of the limited strength model to exercise behaviour. Those authors also suggested that more formal research in the area of exercise and self regulation is warranted.

Applications of the Strength Model to Physical Exercise

Among the earliest investigations of the strength model was a study by Muraven et al. (1998), which employed an isometric handgrip squeeze as an indicator of self control. In this study, participants were depleted using an emotion-suppression manipulation in which participants' emotional response towards an emotionally-upsetting movie clip was manipulated across 3 groups. The 3 conditions consisted of a no emotion control condition where no instructions were given, an increased emotional response condition where participants were instructed to exaggerate emotional responses, and an emotional suppression group who were told to withhold emotional responses to the movie clip. In this three-task experiment, the main dependent measure was the *change* in the amount of time participants were able to sustain squeezing a spring-loaded handgrip. The results showed that handgrip-squeezing endurance went down significantly ($p < .05$) from trial to trial in the exaggerated (mean change = -25.10 sec) and suppressed (mean change = -18.5 sec) emotion groups, while the control group did not change (mean change = -1.57 sec). This study was among the first to illustrate the carry-over relationship between self-control strength depletion of cognitive strength to physical performance.

In an effort to build on Muraven et al.'s (1998) earlier work, Bray, Martin Ginis, Hicks and Woodgate (2008) conducted a more rigorous examination of the effects of cognitive depletion on physical performance. The authors used a different manipulation of self-control depletion, the modified Stroop task (Wallace & Baumeister, 2002), as well as a variation of the isometric handgrip task as a dependent measure. In previous work (e.g., Muraven et al., 1998), physical self regulation was assessed using a spring-loaded handgrip training device with a wad of paper clenched between the handles for as long as possible (i.e., until the wad fell out). Bray et al. (2008) devised a more sophisticated protocol using an electronic force transducer and computer interface that allowed participants to perform a standardized force contraction set at 50% of their maximal voluntary contraction (MVC) to control for individual differences in handgrip strength. The findings reproduced results shown in earlier work with depleted participants exhibiting greater declines in a second endurance handgrip task compared to controls.

In addition, these researchers measured muscle activation in the forearm muscles that contribute to the handgrip task. They found that participants in the depletion group showed greater muscle activation throughout the second endurance trial without any increase in the amount of force they generated in the handgrip squeeze. These findings suggest that the cognitive self control exerted to perform the Stroop task also caused neuromuscular fatigue to occur independent of any physical exertion or energy expenditure.

Although Bray et al. (2008) provided some evidence that cognitive self-control depletion may have implications for the experience of muscle fatigue, the results were limited to isometric handgrip exercise. A more recent study by Martin Ginis and Bray (2010) extended research on the strength model to investigate effects of cognitive depletion on cardiovascular exercise regulation and exercise motivation. This study investigated the effects of self-regulatory depletion on cycling performance, and change in effort of a planned exercise routine. Participants performed a 15-minute stationary cycling task at a cadence of 50 RPM and a self-selected workload corresponding to a rating of 5 on Borg's CR-10 ratings of perceived exertion (RPE) scale in order to establish an individual baseline measure of "moderate-hard" exercise effort (Borg, 1998). In addition, participants created a 30-minute exercise routine that they planned to do at the end of the experiment consisting of 6 exercises they selected from a list of exercises requiring varying levels of RPE. After planning their exercise routine, half of the participants completed the modified Stroop task to deplete their self-control strength and the other half completed a non-depletion control version of the Stroop task. Upon completion of the depletion manipulation, all participants were asked to create an alternate exercise plan similar to the first one, but consisting of a different set of exercises that were also listed according to RPE. Following the exercise-planning task, they performed another cycling task for 15 minutes again at a self-selected workload to achieve a RPE of 5.

The results showed that participants in the depletion group significantly reduced the amount of effort planned for their exercise task while the control group planned the same amount of effort for their workout. Furthermore, despite the fact that all participants cycled at self-selected RPE of 5 for both exercise tasks, the depletion group showed a greater reduction in exercise workload on the cycling task (M = -5.23kJ) compared to controls (M = -2.8kJ). These findings suggest that being cognitively depleted has a negative effect on motivation to invest physical effort into planned exercise tasks, as well as endurance cycling performance. This result is presumably due to depletion of self-control strength that is required to exercise at even a moderate level of intensity. The findings also support Bray et al.'s (2008) results indicating that cognitive depletion causes greater fatigue, which can cause exercise tasks to feel harder to perform in comparison to being in a non-depleted state.

Considered together, the research of Martin Ginis and Bray (2010) and Bray et al. (2008) shows that self-control strength may be an integral component of exercise motivation as well as people's physiological experiences when they engage in effortful exercise tasks. However, there is a lack of research that would allow for a full understanding of how self-control strength may limit or enable adherence to a program of regular exercise over time. Furthermore, there has been no exploration of the role of self-control strength involving exercises that require strenuous cardiovascular effort. Clearly, more research exploring the role of self-control strength in exercise is needed.

The present study aims to extend the literature and examine the effects of self-control strength depletion under conditions of high-intensity cardiovascular exercise. This research will also investigate the impact of construal-level mindsets on self- egulation during exercise behaviour. Some literature suggests that conceptualizations of an activity may affect the level of depletion, for example depending on how a task is viewed (in an abstract or concrete sense) the task can be made to be more or less depleting (Agrawal & Wen Wan, 2009).

Construal Level Theory

Extending our understanding of the role of self-control strength in people's exercise behaviour is one of the major goals of this thesis. However, exercise, like any behaviour, can be perceived in a variety of ways. In fact, the same exercise experience can be perceived differently by the same person if s/he adopts different levels of action identification. Vallacher and Wegner (1987) proposed a theory that human behaviour is represented at different cognitive levels of action identification ranging from higher levels at which actions are thought of in terms of "why" the action is performed, to lower levels, which involve "how" something is performed. For example, at a high level of action identification, a 30-minute vigorous-intensity ride on a stationary bike could be thought of as working to improve health or as an integrated component of a weight-loss program. However, the same 30-minute bike ride could also be thought of at a lower level of action identification as gritting your teeth, straining your leg muscles, grasping the handles, and pushing hard with your feet as you rotate the pedals of the bike.

A more comprehensive theory developed by Trope and Liberman (2003), the construal level theory (CLT), proposes that any object, action or event can be thought of along varying levels of abstraction. Their theory proposes that all objects and events contain details pertaining to higher (more abstract) or lower (more concrete) levels of construal and while people may have tendencies to perceive objects and actions predominantly at one level of abstraction or another, they also have the capacity to change their perceptions of action construals.

Early studies by Trope and Liberman (1998) showed that when objects, actions or events are conceptualized at greater or lesser temporal distance, they take on more abstract high-level details when more distal in time and more concrete low-level details when more proximal. In this work, the researchers presented participants with Vallacher and Wegner's (1987) Behavioural Identification Form (BIF) and asked them to complete the questionnaire under the assumption that the activities would be performed either proximally or distally in time. The authors found that individuals asked to imagine the activities more distally in time were more likely to select the more abstract identification of each behaviour on the questionnaire.

More recent studies have since explored methods of manipulating whether individuals are focused on low- or high-level details of an action or object. A study by Freitas, Gollwitzer and Trope (2004) examined the effects of a mindset-inducing exercise on linguistic indicators of abstract or concrete thinking. Using this methodology, a concrete (low level) mindset exercise consists of asking participants *how* a behaviour, such as "improving and maintaining health" is performed. The initial response must be followed by another answer explaining how that behaviour is performed and this is repeated 4 times. The abstract mindset exercise is identical to the concrete exercise, but instead, participants are asked *why* "improving and maintaining health" is performed. The results of the study showed that participants used more abstract descriptions of the behaviour when manipulated using the *why* exercise and used more concrete words when exposed the *how* exercise, with a large effect size (Cohen's d = 1.47, Cohen, 1992). This method has since been used in several studies to manipulate construal levels (Fujita, Trope, Liberman & Levin-Sagi 2006; Liberman, Trope, McCrea, & Sherman, 2007)

Construal Level Theory and Self-Control

The level of action identification or construal that applies to an activity can clearly vary across, and even within individuals under different circumstances and activities (Trope & Liberman, 1998; Vallacher & Wegner, 1987). The ability for people to have varying construal levels has led researchers to consider the role of construals in the experience of self regulation.

Research by Vallacher and Wegner (1989) has shown that individuals have trait tendencies or spontaneously adopt certain construal levels pertaining to different activities. However, as discussed above, Trope and Liberman (1998) found that construal levels can be influenced through experimental manipulation of psychological distance (social, temporal, physical or hypotheticality). When an object or action is cognitively represented at a greater psychological distance, it primes a mindset associated with high-level construals and a closer psychological distance primes low-level construals (Liberman, Sagristano, & Trope, 2002; Liberman, Trope & Stephan, 2007). Freitas et al. (2004) also demonstrated that construal levels can be primed by engaging in tasks that require one to either think about *why* (high level) or *how* (low level) an action is performed.

Although research has shown that construal levels can be manipulated to higher and lower levels of abstraction, an interesting feature of this research is that the mindset primed by the manipulation is found to carry over to subsequent tasks. For example, in Freitas et al.'s (2004) study, individuals made to think of *why* they performed an action were found to apply that abstract mindset to a subsequent task as well. This finding provided the basis for more recent studies investigating the influence of mindsets on behavioural self control (Fujita et al., 2006).

In one illustrative paper, Fujita et al. (2006) extended construal level research by investigating the effect of manipulated concrete or abstract mindsets on self-control behaviour. The authors suggested individuals in an abstract sense place greater value on the goals of self control and are able to delay immediate gratification to pursue future goals or rewards. One study manipulated the mindset of individuals using the *why* and *how* thought exercise described above (Freitas et al., 2004). Individuals were then asked to bid a dollar amount they would be willing to spend on several items (e.g., a DVD player) to be received either immediately or later on in time. They hypothesized that people with poorer self control to delay gratification should evaluate the item to be more valuable (offered a larger monetary amount) in the present compared to the future. Meanwhile individuals with higher self control to delay gratification should bid a consistent value across both time points. Thus, higher self control was demonstrated by offering the same dollar amount in the present moment and in the future. The results showed that individuals placed into an abstract mindset offered less money for the immediate vs. the future purchases (difference = $35.00) compared to those in a concrete mindset (difference = $45.30) and therefore exhibited greater self control by placing less value on the immediate rewards.

Another highly relevant study by Fujita et al. (2006) investigated the effects of construal levels on self control using performance on an endurance handgrip squeeze as a main dependent measure of self regulation. The construal level manipulation was the *why* and *how* thought task described above (Freitas et al., 2004). The main measure of self control was the difference in time between a baseline handgrip squeeze, and a post-manipulation handgrip squeeze. All participants were encouraged to squeeze the handgrip for as long as possible in order to assist the researchers in determining the accuracy of what was actually a bogus test of important personality characteristics. In other words, they were given a superordinate goal or abstract reason to persist for as long as they could at the handgrip task. Results showed that participants induced into an abstract mindset persisted longer at the handgrip task compared to baseline (mean change = +11.1 sec), whereas those in the concrete mindset squeezed the handgrip for less time (mean change = -4.9 sec). These findings indicate that despite being prompted to endure the handgrip task for as long as they possibly could, people in the concrete mindset were less able to over-ride their immediate temptations to let go of the handgrip when experiencing the discomfort of fatigue. In contrast, those in the abstract mindset were not as encumbered by their immediate discomfort and exerted greater levels of self control in pursuit of the task's higher-level goal of advancing the personality test.

Although abstract mindsets have been found to promote better self regulation, recent research has also found that high construals may not always be beneficial for self-control behaviour. A study performed by Schmeichel, Vohs and Duke (2011) investigated the effects of construal levels on performance of a behavioural self-control task: the stop-signaling task (SST). In the SST, participants are presented with a series of numbers on a computer screen, and when two identical (i.e., matched) numbers appear, a specific keyboard button is to be pressed. Occasionally, a matching number appears in a different colour of ink, indicating a *stop* signal at which time participants are to suppress the response to press the button. In this study, Schmeichel and colleagues found that individuals manipulated into low-level construal performed the stop-signaling task better than participants in a high-level construal. That is, the low-level construal group correctly inhibited more button presses when the stop signal appeared than the high-level construal group.

When interpreting their findings, the authors suggested that in a simple response inhibition task, individuals rely on environmental cues to stifle their habitual or learned action. They reasoned that because a low-construal mindset should make people be more attentive to their immediate surroundings and concrete, procedural features of the task, participants in the low-construal condition exhibited greater self control than the high-construal group.

Schmeichel et al. (2011) went on to theorize that only simple response inhibition behaviours that rely on local cues should be facilitated by low construals, while tasks requiring goal maintenance would benefit from high construals. They tested this hypothesis in 2 other conditions in their 2 (high vs. low construal) X 2 (SST vs. modified SST) design using a modified version of the SST, which included an additional rule requiring participants to press the button on every 3rd *stop* signal. The additional rule represented a form of goal maintenance, an executive process that requires working memory. Schmiechel and colleagues postulated that if working memory is necessary to cue self control in a self-control task (i.e., remembering to push the button every 3rd trial) instead of (or in addition to) using environmental cues to signal self-control behaviour, then people with high-level construals would exhibit better self control than people with low-level construals. The results of the study supported this idea, showing that the high construal group had higher performance in the SST when combined with goal maintenance compared to the low construal group. Thus, Schmeichel et al. (2011) illustrated that the effects of construals on self control may be moderated by the executive demands of the self-control behaviour.

The research carried out thus far provides evidence that altering construal levels has an impact on self-control success across many different behaviours (Fujita, 2008; Fujita et al., 2006; Schmeichel et al., 2011) and that the effects of construals on behavioural self control may differ depending on characteristics of the self-control task (Schmeichel et al., 2011). Although the only study investigating the effects of construals on a physical exercise task (Fujita et al., 2006) has shown that high-level construals lead to better performance than low construals, more extensive research must be conducted before the results may be applied to other forms of exercise behaviour. Because intense cardiovascular exercise is another form of self-control behaviour (cf. Martin Ginis & Bray, 2010), different construal mindsets should lead to different performance in exercise behaviours (e.g., greater self control of exercise workload). However, it is questionable as to what results would be predicted. Based on the early research by Fujita et al. (2006), it would be predicted that by priming an abstract mindset, superordinate goals associated with performing cardiovascular exercise (e.g., contributing to good health, feeling energized) should be the focus of self control and thereby facilitate greater exercise performance. Yet, the research of Schmeichel et al. (2011) has challenged that perspective and would predict that by priming a concrete mindset, subordinate features of the performing cardiovascular exercise (e.g., maintaining a steady pace of pedaling and breathing) should be the focus of self control and thereby facilitate greater exercise performance. Thus, another objective of the present research was to investigate the effects of high- and low-level construals on self control of cardiovascular exercise.

Construal level theory and the strength model

The handgrip exercise experiment (Study 2) by Fujita et al. (2006) draws together several overlapping issues related to construals, self control, and physical activity. However, despite incorporating a physical test of self-control strength, there was no investigation of self-control strength depletion. Thus, the interactive effects of construal levels and self-control strength depletion on self control of physical exercise are unknown.

Although not related to physical activity, two recent studies by Agrawal and Wen Wan (2009) tested the relationship between construal levels and the self-control strength depletion effect. The authors proposed that the depletion effect is a result of greater attentional focus on limited availability of self-control resources after an initial act of self control. They hypothesized that if focus is placed on the abstract goals (induction of a high level of construal) then individuals that were depleted would be able to exhibit greater levels of self control than depleted individuals induced to low-level construals.

The first study tested the idea that individuals at a lower level of construal would show the depletion effect. Self-control strength was manipulated to create depleted or non-depleted groups through a reading task; a health message about contracting Hepatitis C that indicated either a high risk of contracting the disease (depleting task), or a low risk (non-depleting task). Participants were then placed into a high or low level of construal by describing activities (e.g., watching T.V.) either in the distant (a year from now) or near future (tomorrow; Liberman & Trope, 1998), respectively. The main dependent measure of self control was the persistence at reading a passage describing health benefits of dental flossing (also shown in pilot work to consume self-regulatory resources) as well as the amount of time spent flossing during a follow-up period. Results showed that in the depletion condition, individuals in the high-construal mindset exhibited greater persistence at reading the health message ($M = 4.97$ minutes) compared to low-construal ($M = 2.79$ minutes). Notably, individuals that were depleted and in the high-construal condition performed equally as well as non-depleted individuals in the low- ($M = 5.18$ minutes) and high-construal ($M = 5.04$ minutes) conditions ($p > .05$). In addition, low-construal participants that were depleted spent less time flossing ($M = 2.11$ minutes) compared to the non-depleted low-construal condition ($M = 2.74$ minutes). However in the high-construal condition there were no differences ($p > .05$) between the depleted and non-depleted groups. These findings support the idea that high-level construals facilitate performance of self-control behaviour even when people are depleted of self-control strength.

The second study used a similar study design with a slight modification. As indicated by Fujita et al. (2006; Experiment 4) an important factor in using high-level construals to facilitate behaviours is the value of goal-related information. Therefore in this second experiment a third variable was added that varied goal information on the main dependent self-control task. Again participants' self-control strength was manipulated using the depleting health risk message about Hepatitis C with low (non-depleting) and high (depleting) risk as the two conditions. The construal level was manipulated using the means- or ends-related thought task developed by Freitas et al. (2004). A key difference between this study and the previous one was the variation in the relevance of the goal; the dependent self-control task (reading a threatening health message) was either a) high importance or value, b) low importance or value, or c) ambiguous in its relevance to the participants. As predicted, the results showed that in the low-construal group, depleted individuals read for a significantly shorter time (M = 3.02 minutes) than the non-depleted (M = 4.35 minutes; $p < .001$). Meanwhile in the high-construal condition, self-control success varied with the value of goal information. Those in the high-value information condition (M = 4.90 minutes) read for significantly longer than those with goal information that was low in value (M = 3.36; $p < .001$). These results support previous findings (Fujita et al., 2006) showing that high construals benefit self control when self-control tasks involve working memory or superordinate goal information.

Statement of the problem

The present paper aimed to extend research on the effects of self-control strength depletion and construal levels in concert, on self control of a strenuous cardiovascular exercise task. As the literature suggests, adopting high-level construals facilitates self-control behaviour and aids in persistence at physical self control (Fujita et al., 2006). However, it is also well documented that self control is compromised by prior acts of self control, which utilize self-control strength and result in the depletion effect (Hagger et al., 2010). Although there is some work that has attempted to unify the strength model and construal level theory (Agrawal & Wen Wan, 2009), there has yet to be an application of these combined perspectives on self control to physical activity. The present study addressed this gap and utilized a 2 (high vs. low construal) X 2 (depleted vs. non-depleted) factorial design to investigate the main and interactive effects of self-control strength depletion and construal levels on self-controlled performance (i.e., workload or power output) of effortful physical exercise.

HYPOTHESES

Main effects

Hypothesis 1: Based on Fujita et al.'s (2006) work, it was predicted that high construal mindsets facilitate self control, and therefore the high construal group would perform at a higher workload than the low-construal group.

Alternate Hypothesis 1: Based on Schmeichel et al.'s (2011) research it was predicted that low-construal mindsets facilitate self control, and therefore the low-construal group would cycle at a higher workload than the high-construal group.

Hypothesis 2: Based on the strength model of self control and past research, it was predicted that participants who are depleted of self-control strength would cycle at a lower workload than participants in the control group that have not been depleted of self-control strength.

Interaction effects

Hypothesis 3: Drawing from research by Agrawal and Wen Wan (2009; Study 1), which follows Fujita et al.'s perspective of self control and construals, it was predicted that the depleted low-level construal group would cycle at a lower workload than participants in the other three conditions.

Alternate Hypothesis 3: Based on research by Schmeichel et al. (2011) construals and the self-control strength depletion literature (Hagger et al., 2010), it was predicted that the depleted high-level construal group would cycle at a lower workload than participants in the other three conditions.

Data Analysis Strategy

To investigate both main effects and interaction effects omnibus, the results were analyzed using a 2 (depletion vs. control) X 2 (high vs. low construal) factorial ANOVA, where percentage of baseline workload was the dependent measure. This strategy allowed for evaluation of the hypothesized main effects as well as the interactions while reducing family-wise error. The hypothesized interaction effect was further explored using post-hoc simple contrast analyses.

METHOD

Sample Size Estimate

The effect of construals on handgrip self regulation in Fujita et al.'s (2006) study was a medium-to-large effect size (d = 0.69). The sample size to detect this size of effect with a two-group ANOVA and 80% power at an alpha of (p < .05) was 68 participants (34 per group; Cohen, 1992).

Based on Agrawal and Wen Wan (2009), a comparison across 4 group means with a large effect size (at power = .80 and alpha = .05) required 18 observations per group (total = 72).

Based on the study by Martin Ginis and Bray (2010), the effect size of self-control depletion on the cycling task was expected to be small-to-medium (d = 0.32; Cohen, 1992).

For a similar analysis (two-group ANOVA), to achieve a power of 0.8 with an alpha of .05, the required sample size was 155 per group (total N = 310; Cohen, 1992). Due to resource constraints, recruiting participants to satisfy the sample size requirements for the depletion effect size (N = 310) was not feasible, however this concern was addressed in the experimental design. Specifically, in order to attempt to enhance the potency of the self-control depletion effect, the dose of the cycling task was increased to be more difficult (15 RPE) and, in addition, the dose of the modified Stroop task was increased (i.e., from three minutes and 50 seconds to seven minutes). With the aforementioned sample size/power calculations in mind a recruitment target of 80 participants (20 per group) was set.

Participants and Design

Participants were undergraduate and graduate students (N = 67) between the ages of 18 and 30 (M_{age} = 21.77, SD = 3.46) years and were not colourblind. Although this number fell short of the targeted projection, participant recruitment and testing were truncated due to temporal constraints. The study design was a single blind, 2 (depletion vs. non-depletion) X 2 (low construal vs. high construal) factorial arrangement. Participants were stratified by gender and assigned to one of the four different conditions through the use of a random number generator (www.random.org). Participant recruitment was completed through the use of advertisements posted on the McMaster University campus and through the use of an email contact list of participants in previous health psychology studies. The McMaster research ethics board (MREB) approved the research protocol prior to any recruitment and data collection.

Measures

Cycling Power. The average energy expenditure (revolutions per minute x resistance; recorded in kilojoules: kJ) during a period of cycling on an electronically-braked cycle ergometer (Lode Corival™) was collected via a PC-interface and converted to cycling power (watts; W). Watts represent units of energy over a period of time.

Cycling power as a behavioural measure of self control was computed as a percentage of baseline power performed during a cycling test trial. Specifically, participants performed a baseline cycling power test for 2 minutes at a self-selected workload sufficient to evoke a rating of perceived exertion (RPE) of 15 (Hard) on Borg's 16-point RPE scale (Borg, 1990). For the test trial task, the workload setting of the ergometer was reset to zero and participants were instructed to cycle for 10 minutes while adjusting the workload setting to a level that consistently evoked a RPE of 15. In order to control for individual differences, test trial power values were normalized by dividing each participants average test trial power output by their average baseline power and multiplying the value by 100 to derive a power output percentage.

Manipulations

Self-control depletion. Participants in the depletion condition performed a modified Stroop task (Wallace & Baumeister, 2002). Participants were instructed to read aloud from a list of words (e.g., blue, red, pink) printed in different colours of ink. Participants had to over-ride the dominant response of reading a word presented in the printed text and, instead, say aloud the colour of ink. For example, the word "blue" printed in yellow ink would require saying "yellow". The task also involved a second rule requiring participants to ignore the first rule when presented with a word printed in "red" ink. In these cases, participants were asked to say aloud the word represented in by the text (e.g., the word "blue" printed in red ink would require saying "blue"). This manipulation has been shown to effectively induce self-control depletion in several previous studies (e.g., Bray et al., 2008; Martin Ginis & Bray 2010) and shown to have a moderate depletion effect (d = 0.40; Hagger et al., 2010). Participants in the depletion condition performed the modified Stroop task for 7 minutes. Participants in the control condition sat stationary in a comfortable chair and rested quietly for 7 minutes.

Construal level. A construal manipulation consisting of a word-listing task (Fujita et al., 2006) served to induce either a low- or high-construal mindset. All participants were presented with a list of 40 target words (e.g., "dog") on a sheet of paper and an adjacent blank upon which to write a response. Participants in the high-level construal group were instructed to write a category of objects that encompassed the presented word on the adjacent blank. For example, for the word "dog", participants might write "pets". Participants in the low-level construal group were instructed to write an example for the presented word. For example, for the word "dog", participants might write "golden retriever". This manipulation has been found to induce high and low mindsets in previous construal and self-regulation studies (Agrawal & Wen Wan, 2009; Fujita et al., 2006).

Manipulation Checks

4-item self-control manipulation check. In order to check the effectiveness of the depletion manipulation, a 4-item measure of fatigue, effort, pleasantness and task difficulty was used. Participants rated each item using a 7-point scale. The items were as follows: 1) *How much mental effort did you exert while doing the task?* (1 = *Little Effort* and 7 = *Extreme Effort*), 2) *How tired do you feel after doing the task?* (1 = *Not Tired* and 7 = *Extremely Tired*), 3) *How frustrated do you feel after doing the task?* (1 = *Not Frustrated* and 7 = *Extremely Frustrated*), 4) *How pleasant did you find doing the task?* (1 = *Extremely Unpleasant* and 7 = *Extremely Pleasant*). This manipulation check has been used in previous studies involving the modified Stroop task (e.g., Bray et al., 2008; Muraven et al., 1998).

Construal manipulation check. The participants' responses to the category-exemplar task were scored by 2 independent raters that were blind to the each participant's study condition allocation. The raters created a composite score for the responses (+1 for a category, -1 for an exemplar) and scores analyzed using Pearson's *r* for inter-rater reliability (Fujita et al., 2006) where a high correlation indicated high agreement between raters.

Procedure

Individuals were invited to the lab and were asked to sign informed consent as well as complete a demographic and exercise history questionnaire to screen for contraindications to moderate-to-heavy intensity exercise. After adjusting the seat, pedal and handle height on the ergometer, participants were then given 1-2 minutes to familiarize themselves with the exercise equipment and electronic workload adjustments. Importantly, participants were only able to adjust the workload settings on the ergometer using electronic up/down arrows and did not receive information about the actual workload settings throughout the experiment. Once the participants were comfortable with the settings and operation of the ergometer, they performed a warm-up cycling task with no resistance for 2 minutes. After this period, participants were asked to adjust the workload settings to establish a workload on the ergometer that evoked an RPE of 15. Once the RPE of 15 was reached, they signaled to the experimenter to start recording the 2-minute baseline power task. After 1 minute the participant was given the instruction "I would just like to remind you that you can increase OR decrease the intensity just make sure you are always cycling at a resistance that feels like HARD or 15 along the RPE scale." After completing the 2-minute baseline test, participants then completed a 2-minute cool-down task pedaling at zero resistance and were given a drink of water.

Participants in the depletion condition then performed the modified Stroop task for 7 minutes while those in the non-depletion group sat quietly for 7 minutes. After the 7 minutes, all individuals completed the 4-item manipulation check for effort, fatigue, frustration and pleasantness. Following the depletion manipulation, participants completed either the high- or low-level construal manipulations for a period of 5 minutes. For all participants, the total amount of time between the cycling tasks was held consistent at 14 minutes.

Participants then returned to the cycle ergometer and cycled for a 2-minute warm-up period at no resistance. Following the warm-up, participants were instructed to continue pedaling and adjust the workload setting to a level that evoked a rating of 15 on the RPE scale, at which point they signaled to the experimenter to begin the cycling test trial. After 1 minute, participants were again given the instruction "I would just like to remind you that you can increase OR decrease the intensity just make sure you are always cycling at a resistance that feels like HARD or 15 along the RPE scale." Participants continued to cycle, and were given the same instruction about maintaining an RPE of 15 at 3 minutes and 7 minutes into the trial. After 10 minutes had elapsed, recording for the test trial was terminated and participants were informed that "sufficient data have been collected for the experiment, however you are welcome to continue to cycle and get a good workout or you can stop at anytime". After they completed cycling, participants were debriefed and all deceptions were explained. Participants were then thanked for their time and contribution to the study and remunerated $10 for their participation.

RESULTS

Data screening and tests for normality

The distribution of scores for the main dependent variable (test trial cycling power) was inspected for skewness and kurtosis and plotted on a histogram to examine the assumption of normality. There were two outliers that had scores greater than 3 standard deviations from the mean. These data as well as consultation of the experimenter's notes indicated these participants were unable to correctly use the bike apparatus to cycle without making drastic adjustments to the workload settings during cycling and therefore were removed from the dataset. After the outliers were removed the data better fit the normal distribution curve although the sample size was reduced to 65.

Participants' scores on the demographic and physical activity measures were assessed to check for equivalency across conditions (see Table 1). A one-way ANOVA indicated no significant differences between groups in age, F (3, 61) = .09, p = .96. One-way ANOVA also showed no differences between groups for moderate-to-vigorous physical activity, F (3,61) = .99, p = .41.

Table 1

Descriptive Statistics of Participant Distribution by Group, Age and Exercise patterns

	Low Construal		High Construal	
	Depleted	Non-Depleted	Depleted	Non-depleted
Number of participants	18	16	15	16
Age	21.72 (3.30)	21.93 (3.71)	21.33 (3.28)	21.87 (3.68)
Moderate-to-vigorous activities per week	2.75 (1.55)	4.03 (2.38)	3.76 (3.63)	2.96 (2.28)

Note. Standard deviations are presented in parentheses. Moderate-to-vigorous activities (MVPA) per week = number of sessions of >30 minutes of continuous MVPA.

Baseline testing and manipulation checks

In order to ensure that all groups were equivalent at baseline, the power output on the initial baseline task in watts (W) was tested using a simple ANOVA. The analysis indicated that there were no significant differences of baseline power output between groups F (3,58) = 1.60, p = .20. Responses to the 4-item measure were evaluated between the depletion and non-depletion groups using independent sample t-tests (Bray et al., 2008; Muraven et al., 1998). There were significant differences between groups for all measures, reflecting greater levels of mental effort t (63) = -11.64, $p < .001$, fatigue t (63) = -4.50, $p < .001$, frustration t (63) = -4.55, $p < .001$, and unpleasantness t (63) = 4.01, $p < .001$, in the depletion condition.

The results of the construal manipulation check showed participants in the high-level construal group scored an average of 30.97 (SD = 6.77) and participants in the low-level construal group scored an average of –33.01 (SD = 5.61). The t-test showed significant difference between conditions t (63) = -41.23, $p < .001$. These results confirm that participants responded to the construal manipulation in the manner intended. There was a high inter-rater correlation (r = .93, $p < .001$), which indicated strong agreement among raters.

Main hypothesis testing

Hypothesis 1. *Based on the literature by Fujita et al. (2006) it was hypothesized that the high-construal group would cycle at a higher percentage of baseline power output than the low-construal group.*

Alternate Hypothesis 1. *Based on Schmeichel et al. (2011) it was predicted that the low-construal group would cycle at a higher percentage of baseline power than the high-construal group.*

Descriptive statistics for the construal conditions are presented in Table 2. The hypothesis was tested using a 2 (low vs. high construal) X 2 (depletion vs. non-depletion) factorial ANOVA with percentage change in cycling power output from baseline to the test trial as the dependent variable. Contrary to the hypothesis, there was no significant main effect for construal level, F (1,61) = .16 p = .69.

Table 2

Cycling Power by Time and Test Trial Performance as a Percentage of Baseline by Construal Condition.

Dependent Measures	Low Construal	High Construal	*p*-value
Baseline (W)	121.02 (45.31)	120.94 (57.11)	.97
Test trial (W)	99.25 (41.27)	99.70 (51.64)	.98
Percentage of baseline	83.20% (20.54)	81.23% (19.05)	.69

Note. Values represent group means. Standard deviations are presented in parentheses

Hypothesis 2. *It was hypothesized that the cognitive depletion group would have a larger decrease in power than the non-depletion group.*

Descriptive statistics for the depletion conditions are presented in Table 3. The hypothesis was tested using a 2 (low vs. high construal) X 2 (depletion vs. non depletion) factorial ANOVA with percentage change of cycling power output during the test trial as the dependent variable. Contrary to the hypothesis, results indicated no main effect for self-control depletion, $F\,(1,61) = .16$, $p = .69$.

Table 3

Cycling Power (W) by Time and Test Trial Performance and as a Percentage of Baseline by Self-control Strength Depletion Condition.

Dependent Measures	Depletion	Non-depletion	*p*-value
Baseline (W)	116.61 (54.94)	125.50 (46.74)	.49
Test trial (W)	96.59 (50.24)	102.42 (42.08)	.58
Percentage of baseline	81.56% (22.58)	82.99% (16.59)	.69

Note. Values represent group means. Standard deviations are presented in parentheses

Hypothesis 3. *In accordance with the study by Agrawal and Wen Wan (2009) it was hypothesized that there would be an interaction effect between construal levels and self-control depletion, showing that low-construal depleted group would have the largest decrease in power.*

Alternate Hypothesis 3. *However according to research by Schmeichel et al. (2011) it was hypothesized that there would be an interaction effect showing that the high-construal depletion group would have the greatest decrease in power.*

Descriptive statistics for the depletion conditions crossed with construal conditions are presented in Table 4. The hypothesis was tested using a 2 (low vs. high construal) X 2 (depletion vs. non depletion) factorial ANOVA with percentage change of cycling power output during the test trial as the dependent variable. Analysis of cycling power over the 10-minute test-trial period showed a non-significant trend for an interaction effect, (F (1,61) = 3.42, p = .07).

Although the interaction was not significant at $p < .05$, the fact that there were fewer participants in the study than planned prompted further examination of the construal level X depletion interaction effect using a series of post-hoc simple contrasts. Results of the post-hoc tests are presented in Table 5. As shown in Table 5, despite the near-significant interaction effect, the post-hoc results indicated no significant ($p > .05$) differences between groups. However, decomposition of the factorial arrangement resulted in substantial reductions in statistical power due to sample size restrictions. Consequently, effect sizes (Cohen's *d*; Cohen, 1992) were computed to assess the magnitude of the differences between the group means. To evaluate the hypothesized effects, it is necessary to independently examine the contrast effect sizes between the low construal/depletion condition and the other three conditions as well as the contrast effect sizes between the high construal/depletion condition and the other three conditions.

Hypothesis 3 predicted that the low construal/depletion condition would show greater reductions in performance as a percentage of baseline workload power in comparison to the other three conditions. As shown in Table 5, in the darker gray shaded cells, the depleted low construal group did not follow the predicted trend following Agrawal and Wen Wan (2009). That is, instead of performing the worst of the three groups, the depleted low-construal group actually performed as well or better than the other three groups.

Alternate Hypothesis 3 predicted that the high construal/depletion condition would show greater reductions in performance as a percentage of baseline workload power compared to the other three conditions. As shown in Table 5, by the light grey shaded cells, the depleted high construal followed the predicted trend; performing the worst of the three groups. Considered together, the findings that the low-construal depletion group performed as well, or better, than the other groups and the high-construal depletion group performed the worst of all the groups is consistent with alternate hypothesis 3.

Table 4

Cycling Power (W) by Time and Test Trial Performance and as a Percentage of Baseline for Self-control Strength Depletion Conditions Crossed with Construal Level Conditions.

	Low Construal		High Construal	
Dependent Measures	Depleted	Non-depleted	Depleted	Non-depleted
Baseline (W)	119.16 (52.34)	123.12 (37.44)	113.55 (59.62)	127.87 (55.69)
10 minutes (W)	102.92 (50.70)	95.12 (28.29)	89.00 (50.35)	109.72 (52.40)
Percentage of baseline	86.54% (23.43)	79.45% (16.69)	75.58% (20.72)	86.53% (16.23)

Note. Values represent group means. Standard deviations are presented in parentheses

Table 5

Summary Results of Post-hoc Simple Contrasts Percentage of Baseline Scores Between Study Conditions

Comparing group	Other groups	Difference	*p*-value	Cohen's *d*
Depleted Low-construal	Non-depleted Low-construal	7.08%	.32	.35
	Depleted High-construal	10.95%	.17	.50
	Non-depleted High-construal	0.01%	1	.00
Non-depleted low-construal	Depleted Low-construal	-7.08%	.32	-.35
	Depleted High-construal	3.87%	.57	.21
	Non-depleted High-construal	-7.08%	.23	-.43
Depleted High-construal	Depleted Low-construal	-10.95%	.17	-.50
	Non-depleted Low-construal	-3.87%	.57	-.21
	Non-depleted High construal	-10.95%	.11	-.59
Non-depleted High-construal	Depleted Low-construal	0.01%	1	.00
	Non-depleted Low-construal	7.08%	.23	.43
	Depleted High-construal	10.95%	.11	.59

DISCUSSION

The purpose of the present study was to investigate the effects associated with self-control strength depletion and construal levels on self control of a strenuous cardiovascular exercise task. Based on previous research on the construal theory, two hypotheses for main effect of construals were advanced, however, neither hypothesis was supported. Similarly, the hypothesis guided by the strength model of self control was not supported. The third hypotheses that predicted an interaction between construal level and self-control strength depletion showed a trend towards a significant effect. The nature of the interaction was more consistent with Schmeichel et al.'s (2011) work, and therefore supported alternate hypothesis 3. Although the overall set of findings did not support the a priori hypotheses, they allow for reasonable interpretation in light of theory and previous findings and have implications for future research and practical application.

Hypothesis 1: It was predicted that individuals in the high-construal group would cycle at a higher percentage of baseline power than the low-construal group.

Alternate Hypothesis 1: It was predicted that individuals in the low-construal group would cycle at a higher percentage of baseline power than the high-construal group.

Given two opposing streams of literature on the effects of construal levels and self-control tasks, two possible hypotheses for the changes in self-control performance of the exercise task were proposed. The results did not provide support for either hypothesis. Thus, based on the analysis of the main effects in the present study, there was no effect of construal level on self-control performance of a strenuous cardiovascular exercise task. However, as will be discussed, more focused analysis of the four experimental conditions allows for further interpretation to be made.

Hypothesis 2: It was predicted that the self-control depletion group would cycle at a lower percentage of baseline power compared to the non-depleted group.

In line with the substantial evidence for the effects of self-control depletion, it was hypothesized that the depleted group would perform significantly worse than the non-depleted group (Hagger et al., 2010). Unexpectedly, the findings of the current study did not support this prediction, as there were no significant differences between the depleted and non-depleted groups. In fact, examination of the main effects showed the depletion and non-depletion groups differed by less than 2% in their performance of the strenuous cycling task.

Although the present findings do not support the strength model of self control, it is important to point out that evaluation of the simple main effect for self-control depletion is complicated by the differential exposure of participants to the construal manipulations. In short, a fair test of the strength model of self control would focus on two conditions in which the depletion effect was investigated in isolation. In a previous study by Martin Ginis and Bray (2010), self-control depletion was shown to have a small-to-medium effect on performance at an endurance cycling task however these results were not replicated. In the current study, it is possible that exposing half the sample to a high-construal manipulation and the other half to a low-construal manipulation neutralized the depletion effect. However, as will be discussed, the construal manipulations appeared to set the stage for different effects to emerge depending on levels of construals and levels of depletion.

Hypothesis 3: It was predicted that the depleted low-construal group would cycle at the lowest percentage of baseline power compared to all of the other 3 conditions.

Alternate Hypothesis 3: It was predicted that the depleted high-construal group would cycle at the lowest percentage of baseline power compared to the 3 other conditions.

The above predictions differ substantially from one another and were drawn from previous research by Fujita et al. (2006), Schmeichel et al. (2011), and Agrawal and Wen Wan (2009) that focused attention on the self-control vulnerability of one of the study conditions in relation to the others. The results of the factorial analysis revealed an interaction effect that was marginally significant (p = .07). However the results did not support either hypothesis per se. Rather, independently analysis of the 4 conditions supported both hypotheses. The nature of the interaction showed the effects of construals and self-control depletion on self-control performance of a strenuous exercise task may work in opposing directions and need to be interpreted accordingly.

Earlier it was discussed that there was no main effect for construal level. However, because some participants did not partake in a depletion manipulation, the two study conditions comprising the non-depleted group align methodologically with the research by Fujita et al. (2006) in that those studies did not manipulate self-control strength. In Fujita et al.'s studies, high construals were associated with greater self-control performance than low construals. Examination of the group means and effect sizes (Tables 4 and 5) in the present study show a similar trend to Fujita et al.'s findings in that the non-depleted high-construal groups outperformed the non-depleted low-construal groups. That is, the effect size representing the difference between the performance means in the non-depleted conditions was in the small-to-medium (d= .43) range, which is typical of construal-level effects seen in past self-control studies (e.g., Fujita et al., 2006). These findings suggest that controlling one's effort to perform strenuous exercise under non-depleted (i.e., control) conditions is facilitated by high-construal mindsets. Thus, the present study supports previous research by Fujita et al. (2006) insofar as showing high-level construals allow for better self control and also extend those findings, which were based on isometric handgrip endurance, to show that construals may also have an effect on self regulation of intense cardiovascular exercise.

Although the construal effects in the non-depleted conditions closely follow trends observed by Fujita et al. (2006), the effects of construals from the depletion groups are more aligned with work by Schmeichel et al. (2011). Consistent with Schmeichel and colleagues, the post-hoc analyses of differences between the means across all four of the study conditions showed that the depleted, low-construal group performed as well as the non-depleted high-construal group and outperformed the other two groups; in particular the depleted high-construal group (d = .51).

Schmiechel et al. (2011) proposed that self-control tasks that require focus on concrete environmental cues should benefit from low-level construals. In the current study, individuals were instructed to maintain a workload that evoked a rating of 15 on the RPE scale. Therefore, they had to monitor their internal cues carefully to follow these instructions. Thus, in a manner analogous to the SST self-control task in the study by Schmeichel et al. (2011) the endurance cycling task did not demand high levels of executive control to perform and did not benefit from high-level construals. According to this perspective, if the self-control task involved greater investment of executive function, such as a superordinate goal that had to be maintained in working memory, then the high-construal group would have shown better self control. As it stands, the results indicate that being depleted and having a high-construal mindset may detract from self control when tasks have challenging physical demands, whereas having a low-construal mindset when depleted may benefit self control of such tasks. Under conditions of depleted self control, low-level construals were found to enhance or preserve self-control performance of intense cardiovascular cycling exercise. This finding is consistent with Trope and Liberman's (2003) theoretical framework. That is, Trope and Liberman (2003) postulate that low-construal mindsets focus on concrete details of a task—the subordinate "how" of the task. A lower-construal mindset is typically induced by thinking in the immediate future or by being close in psychological distance to a target task or object. In contrast, a high-construal mindset is concerned with the abstract details of a task—the superordinate "why" of the task. Trope and Liberman (2003) suggest that high-construal individuals "may therefore start thinking about a future situation in terms of their general knowledge and goals and postpone thinking about the more specific, secondary aspects of the situation until later." (p. 406). If high-construal individuals neglect information on the specific situation at hand, then this distraction could potentially explain the negative performance among the depleted participants on the cycling task. Conversely, participants in the low-construal group may have been focused more on following instructions for how to perform the cycling task and maintaining a consistent pace for the task, which should facilitate self control of their cycling effort. In other words, when one is depleted and engaging in a strenuous physical task, in a high-construal mindset they may be inclined to focus attention on questioning *why* they are working so hard at the task and reduce their investment under ambiguous circumstances (e.g., for the sake of being in a study or for a token monetary incentive). In contrast, when one is depleted and engaging in a strenuous physical task, but in a low-construal mindset, they are in an extremely concrete mindset that promotes task focus, allowing investment of self-regulatory strength on the *how* (vs. *why*) of executing the task at hand.

Further inspection of the data in the present study also support the hypothesis that low-level construals may be beneficial when self-control strength is already depleted. Specifically, supplemental analysis of the data (see Appendix A, Table A) showed that during the first 2 minutes of the test trial, all 4 groups had an equivalent decrease in percentage power output (~10%). However, it was during the latter 8 minutes of the task that group differences emerged (Appendix A, Table B). Indeed, analyses of the latter 8-minute window of data revealed a significant interaction (p = .02) and a large effect (d = .62) between the depleted low-construal group and the depleted high-construal group. These results suggest that during the acute stages of a challenging physical self-control task, the effects of prior depletion and construals are less influential than during later stages when greater self-control resources may be required.

Implications and Future Directions

The present research has several implications for studies incorporating self-control depletion or varying construal levels. As shown by the interaction effect between construals and self-control depletion the current study provides evidence for the interdependence of construal level theory and the strength model of self control. As a result researchers investigating either theoretical framework should keep in mind the potential moderating effects of the opposing theory.

For instance, individuals participating in a self-control depletion study should either indicate their level of construal, or complete a measure of construals to ensure there is no confounding effect on depletion. Previous research has utilized the behaviour identification form (BIF; Vallacher & Wegner, 1987) as a representation of individual construal level and could be used to investigate or control for moderation in future studies of the strength model of self control.

Conversely, the implications of the current findings for construal-level studies of self-control are less substantial. Since the current study showed that using the Stroop task as a means of depletion affected subsequent performance after construal manipulations, it suggests that cognitive depletion would have an impact on the construal manipulation, not vice-versa. Although previous studies have shown that self-control tasks impact construal levels (e.g., Wen Wan & Agrawal, 2011) only the present study and Agrawal and Wen Wan (2009) have explored self-control depletion and construal level manipulations in concert. Therefore, more studies testing different spheres of self control would be required to determine whether self-control strength depletion could affect construal level manipulations. Since typical experimental paradigms for construal level theory research occur in a non-depleted state, there are no implications for the standard method of manipulating construal level in studies of self-control.

Interestingly, the current study found the opposite results to those discovered by Agrawal and Wen Wans (2009). Those researchers found that high construals attenuated depletion effects, yet the current study found that high construals were associated with depletion effects. This result may be due to the fact that there was no superordinate goal for the cycling task in the present study, whereas the health message task in their study required executive function (attention and working memory). Therefore, the main dependent self-control task in the study by Agrawal and Wen Wan (2009) had contrasting demands in comparison to the present study. Future research integrating these theories should consider the simple or superordinate demands of the task as differential predictions may be appropriate.

In terms of practical applications, it appears that when individuals are highly depleted of self control it is important to maintain a low-construal mindset to perform physical exercise (i.e., intense cycling). Thus, for the individual who has exerted considerable self-control throughout the day, it is important to become very concrete in thinking and focus on *how* s/he exercise in order improve exercise effort and performance. Whereas when one is not depleted of self-control (e.g., on a weekend morning or a day off), focusing on the abstract goals or reasons for being physically active can improve exercise performance.

The current research also would benefit clinical populations that struggle with self control. For example drug addicts or people with ADHD may benefit from strength model and construal level research (Barkley, 1997; Baumeister et al., 1994). A recent study showed that tobacco smokers benefit from self-control strength training by reducing their likelihood of a smoking lapse (Muraven, 2010). The current research indicating an interaction effect of construals and self-control depletion adds to this finding as it suggests that changing construal levels may benefit smokers in addition to self-control strength training. Meanwhile, people with ADHD who have issues with impulse control could benefit from interventions that focus their attention at a very concrete level in order to improve self control.

Although the present study lends some insights into the relationship between construal levels and depletion, more research is necessary. One advancement from the current literature would be to investigate whether all forms of self-control depletion interact with construal levels in an identical manner. It is possible that only cognitive depletion leads to the interaction found in the present study, meanwhile depletion in other domains of self control (e.g., behavioural, emotional) could lead to varying results. Additional studies with different depletion measures are necessary to test the reliability of the observed phenomenon more extensively.

In addition, it would be interesting to explore the effects of construal level and self-control strength on different forms of self control. Although the current study revealed differential effects of construal level theory and self-control strength depletion on cycling power output, these results may be a function of the demands of the task. Future research could explore the construal-depletion interaction in other self-control domains such as emotional control and thought suppression. It is possible that there is a priming or practice effect for self control (Oaten and Cheng, 2006) and, therefore, the depletion and construal levels may interact differently depending on the sphere of self control.

Another interesting avenue to pursue would be to explore the mechanism through which these two theories interact. More proximal determinants of why self-control depletion occurs, or how different mindsets improve or impair self-control behaviour would vastly improve predictive power of these theories. The mechanistic properties of why these theories individually impact self control would help explain the interaction effect and would allow further understanding of their effects in concert on self-control failure and success.

Strengths and Limitations

Although the current study presented many interesting results, there were several important limitations that accompany the strengths of this study. Since the sample collected for the study consisted of only university students, the results are applicable to that specific population. Future studies should look at samples that are more representative of the general Canadian population. In addition, it would be interesting to see if there are differential effects as a result of exercise experience.

The current study also aimed to have a sample size sufficient for power of .80. Although an attempt was made to increase the potency of the depletion manipulation, post-hoc analysis indicated that the current study had a power of only .44 for the interaction effect indicating the strategy to increase power was unsuccessful.

Additionally, the study did not fully explore the independent effect of self-control depletion on endurance cycling. As discussed above, in order to do a sound test of the strength model, an additional two groups would have been required. Therefore the results of self-control depletion on endurance cycling exercise shown in the current study cannot be adequately interpreted and incorporated in the self-control strength literature.

On the other hand, there were several strengths associated with the current study. First of all the current study is the first to apply both the construal level theory and the strength model of self control in an exercise context. The current study adds to the findings of Agrawal and Wen Wan (2009) by utilizing a more widely used form of self-control depletion (the modified Stroop task; Hagger et al., 2010) while applying it to a health-relevant behaviour. These results were also considerably different than those found by Agrawal and Wen Wan (2009) and showed that there are differential effects of construal levels and self control that may depend on the types of self-control tasks being performed.

A second important strength of the study was that it has practical health implications in addition to the theoretical importance. The main dependent variable of the current study was a high-priority health behaviour (WHO, 2004) and the results have implications for clinical health` practitioners. For instance, physiotherapists or personal trainers may be able to use the information generated in this study to have clients who are in a depleted state exert more effort and improve exercise performance if they can induce a low-construal mindset. Alternatively, if clients are not depleted of self-control strength, then inducing a high-construal mindset may improve exercise performance. From another practical standpoint, in a typical day where one is a depleted of self-control resources and exercising at the gym, focusing on concrete details may result in higher performance than if induced into a high-construal mindset.

CONCLUSION

In summary, the current research provides further evidence for the interaction between the strength model of self control and construal level theory in self-control behaviours. It appears that depending on the availability of self-control resources as well as the demands of a task, either abstract or concrete mindsets may be beneficial. When a task requires working memory and contains a superordinate goal, and one is not depleted of self-control strength, it appears that abstract mindsets benefit self control. However, for tasks that contain environmental cues for self control, and if self-regulatory resources are depleted, concrete mindsets improves self control. This is the first study to explore these two theoretical frameworks on endurance cycling behaviour and more research exploring the interactive effects of construal levels and self-control strength on self-control behaviours is warranted.

REFERENCES

Agrawal, N., & Wen Wan, E. (2009). Regulating risk or risking regulation? Construal levels and depletion effects in the processing of health messages. *Journal of Consumer Research*, *36*, 448-462.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*, 65.

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

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

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science, 16*, 351-355.

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human Kinetics Publishers.

Bray, S. R., Martin Ginis, K. A., Hicks, A. L., & Woodgate, J. (2008). Effects of self□regulatory strength depletion on muscular performance and EMG activation. *Psychophysiology, 45*, 337-343.

Burgess, P. W. (1997). Theory and methodology in executive function research. *Methodology of Frontal and Executive Function*, 81-116.

Cohen, J. (1992). A power primer. *Psychological bulletin, 112*(1), 155.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). *Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey* (pp. 7-14). Ottawa: Statistics Canada.

Dishman, R. K. (1988). *Exercise adherence: Its impact on public health*. Human Kinetics.

Freitas, A. L., Gollwitzer, P., & Trope, Y. (2004). The influence of abstract and concrete mindsets on anticipating and guiding others' self-regulatory efforts. *Journal of Experimental Social Psychology, 40*, 739-752.

Fujita, K. (2008). Seeing the Forest Beyond the Trees: A Construal□Level Approach to Self□Control. *Social and Personality Psychology Compass, 2*, 1475-1496.

Fujita, K., Trope, Y., Liberman, N., & Levin-Sagi, M. (2006). Construal levels and self-control. *Journal of Personality and Social Psychology, 90*, 351.

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

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin, 136*, 495.

Liberman, N., Sagristano, M. D., & Trope, Y. (2002). The effect of temporal distance on level of mental construal. *Journal of Experimental Social Psychology, 38*, 523-534.

Liberman, N., Trope, Y., McCrea, S. M., & Sherman, S. J. (2007). The effect of level of construal on the temporal distance of activity enactment. *Journal of Experimental Social Psychology, 43*, 143-149.

Liberman, N., Trope, Y., & Stephan, E. (2007). Psychological distance. *Social Psychology: Handbook of Basic Principles, 2*, 353-383.

Martin Ginis, K. A., & Bray, S. R. (2010). Application of the limited strength model of self-regulation to understanding exercise effort, planning and adherence. *Psychology and Health, 25*, 1147-1160.

Muraven, M. (2010). Practicing self-control lowers the risk of smoking lapse. *Psychology of Addictive Behaviors*, *24*, 446.

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

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

Oaten, M., & Cheng, K. (2006). Longitudinal gains in self□regulation from regular physical exercise. *British Journal of Health Psychology, 11*, 717-733.

Schmeichel, B. J., Vohs, K. D., & Duke, S. C. (2011). Self-control at high and low levels of mental construal. *Social Psychological and Personality Science*, *2*, 182-189.

Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychological Review, 110*, 403.

Vallacher, R. R., & Wegner, D. M. (1987). What do people think they're doing? Action identification and human behavior. *Psychological Review, 94*, 3.

Wallace, H. M., & Baumeister, R. F. (2002). The effects of success versus failure feedback on further self-control. *Self and Identity, 1*, 35-41.

Wen Wan, E., & Agrawal, N. (2011). Carryover effects of self-control on decision making: A construal-level perspective. *Journal of Consumer Research*, *38*, 199-214.

World Health Organization. (2004). WHO (2004). *Gaining Health, the European Strategy for Prevention and Control of Non-communicable Diseases*.

APPENDIX A

Supplementary Analysis

TABLE A

Percent of Baseline Cycling Power (W) at 2 Minutes and 8 Minutes of a 10-minute Test Trial by Time and Test Trial Performance for Self-control Strength Depletion Conditions Crossed with Construal Level Conditions

	Low Construal		High Construal	
Dependent Measures	Depleted	Non-depleted	Depleted	Non-depleted
After 2 minutes	93.05% (27.08)	90.66% (20.66)	91.91% (22.20)	95.55% (10.51)
Following 8 minutes	84.92% (23.27)	75.74% (17.04)	71.51% (20.97)	87.65% (23.11)

Note. *Values represent group means. Standard deviations are presented in parentheses.*

TABLE B

Summary of Results of Post-hoc Simple Contrasts Percentage of Baseline Scores Between Study Conditions for the First Two Minutes of a 10-minute Test Trial

Comparing group	Other groups	Difference	*p*-value	Cohen's *d*
Depleted low construal	Non-depleted low construal	2.38%	.78	.10
	Depleted high construal	1.13%	.90	.05
	Non-depleted high construal	-2.50%	.73	-.12
Non-depleted low construal	Depleted low construal	-2.38%	.78	-.10
	Depleted high construal	-1.25%	.87	-.06
	Non-depleted high construal	-4.88%	.41	-.31
Depleted high construal	Depleted low construal	-1.13%	.90	-.05
	Non-depleted low construal	-1.25%	.87	-.06
	Non-depleted high construal	-3.63%	.56	-.22
Non-depleted high construal	Depleted low construal	2.50%	.73	.12
	Non-depleted low construal	4.88%	.41	.31
	Depleted high construal	3.63%	.56	.22

TABLE C

Summary of Results of Post-hoc Simple Contrasts Percentage of Baseline Scores Between Study Conditions for the Last Eight Minutes of a 10-minute Test Trial

Comparing group	Other groups	Difference	p-value	Cohen's *d*
Depleted low construal	Non-depleted low construal	9.18%	.20	.46
	Depleted high construal	13.40%	.10	.62
	Non-depleted high construal	-2.73%	.73	-.12
Non-depleted low construal	Depleted low construal	-9.18%	.20	-.46
	Depleted high construal	4.22%	.54	.22
	Non-depleted high construal	-11.90%	.11	-.61
Depleted high construal	Depleted low construal	-13.40%	.10	-.62
	Non-depleted low construal	-4.22%	.54	-.22
	Non-depleted high construal	-16.1%	.05	-.75
Non-depleted high construal	Depleted low construal	2.73%	.73	.12
	Non-depleted low construal	11.9%	.11	.61
	Depleted high construal	16.1%	.05	.75

APPENDIX B

Consent Form

DATE: ________

LETTER OF INFORMATION / CONSENT

A Study of/about Understanding cognitive and physical performance

Investigators: Alex Tran and **Dr. Steven Bray**

Principal Investigator: Alex Tran
Department of Kinesiology
McMaster University
Hamilton, Ontario, Canada
trana32@mcmaster.ca

Co-Investigator(s): Faculty Supervisor: Dr. Steven Bray
Department of Kinesiology
McMaster University
Hamilton, Ontario, Canada
(905) 525-9140 ext. 26472
sbray@mcmaster.ca

Purpose of the Study
The purpose of this study is to examine the performance of physical endurance exercise and mental challenges under a variety of conditions.

Procedures involved in the Research
This study will take approximately 1 hour to complete. Participation involves cycling on a stationary bike in two separate phases at a moderate to vigorous intensity. The first phase will familiarize you with the equipment. You will then be asked to perform a reading task (reading different coloured words) as well as a task that will require you to think come up with several words that either a category or an example of a target word. In addition you will be asked to fill out questionnaires about the importance of exercise as well as how you conceptualize different behaviours. You will then perform a second bike task.

Potential Harms, Risks or Discomforts:
You might find the cycling exercises to be tiring and experience some minor muscle soreness over the next few days. If you experience any intense pains while doing the exercises you should tell the researcher immediately and stop the exercise. You will also be asked to complete a mentally-challenging task and some survey questions. It is possible you could find some of the questions about your personality, or some of the mental exercises, to be stressful. If you feel uncomfortable performing the mental task you should tell the researcher immediately and discontinue the task. If you feel uncomfortable about responding to any of the survey questions, you may leave those questions blank.

Potential Benefits
Participating in the study will provide a single dose of physical activity. The results from this preliminary study will help the scientific community better understand the effects of cognitive tasks on physical endurance and performance.

Payment or Reimbursement

You will be paid $10 cash for completing this study. If you drop out before completing the study, you will still be compensated. All compensation will be given at the end of the lab session.

Confidentiality
Any information that is obtained during this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The questionnaires are completely private and will be kept in a locked filing cabinet in The Health and Exercise Laboratory for a period of five years. Your name will not be recorded on any of the study documents. Only the researchers and research assistants will have access to this information. Your identity will never be revealed in any reports of this study.

Participation and Withdrawal
You can decide whether to take part in this study or not. If you volunteer for this study you may withdraw at any time without penalty. You can choose to remove your data from the study at any time. You may also refuse to answer any questions you don't want to answer while remaining in the study.

Information about the Study Results
I expect to have this study completed by approximately by June, 2013. If you would like a brief summary of the results, please leave your email contact _______________.

Questions about the Study
If you have questions or require more information about the study itself, please contact me.
This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance. If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Office of Research Services
E-mail: ethicsoffice@mcmaster.ca

CONSENT

I have read the information presented in the information letter about a study being conducted by Alex Tran of McMaster University. I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested. I understand that if I agree to participate in this study, I may withdraw from the study at any time. I have been given a copy of this form. I agree to participate in the study.

Signature: ________________________________

Name of Participant (Printed) ______________________________

APPENDIX C

Demographics Questionnaire

DEMOGRAPHICS

To begin, we are interested in getting to know some basic information about you. Please complete the following questions.

Age: _____

Sex: Female _____ Male _____

EXERCISE SCREENING QUESTIONNAIRE

Do you lift weights for exercise? Yes _____ No _____

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 D

RPE Scale

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

6 No exertion at all
7 Extremely light
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

9 corresponds to "very light" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes

13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.

17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.

19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Ratings of Perceived Exertion

6 No exertion at all

7☐ Extremely light☐

8

9 Very light

10

11 Light

12

13 Somewhat hard

14

15 Hard (heavy)

16

17 Very hard

18

19 Extremely hard

20 Maximal exertion

APPENDIX E

4-Item Manipulation Check

4-item Manipulation Check

These items are statements about your reactions to the task you just completed. Please read each statement and circle your response using the scales below.

1. How much mental effort did you exert while doing the task?

1 2 3 4 5 6 7
Little Effort **Extreme Effort**

2. How tired do you feel after doing the task?

1 2 3 4 5 6 7
Not Tired **Extremely Tired**

3. How frustrated do you feel after doing the task?

1 2 3 4 5 6 7
Not Frustrated **Extremely Frustrated**

4. How pleasant did you find doing the task?

1 2 3 4 5 6 7
Extremely Unpleasant **Extremely Pleasant**

APPENDIX F

Construal Level Manipulations

Word-Listing Task

In this task, you will be provided with a series of words. Your task will be to write down a word that is an example of this word. That is, ask yourself the question, "An example of [provided word] is what?" and write down the answer you come up with. For example, if we gave you the word "DOGS," you might write down the example "POODLE" or even "PLUTO" (the Disney character). Be creative, and try to think of as specific an example of the category as you can.

SODA
COMPUTER
NEWSPAPER
PROFESSOR
PASTA
BOOK
SPORT
TABLE
SHOE
MOVIE
PEN
SENATOR
LUNCH
TRAIN
MAIL
ACTOR
BEER
PHONE
SOAP
FRUIT

COIN
RESTAURANT
TREE
GAME
PAINTING
BAG
WATER
COLLEGE
DANCE
CANDY
GUITAR
MOUNTAIN
POSTER
SOAP OPERA
RIVER
MATH
KING
WHALE
SINGER
TRUCK

Word-Listing Task

In this task, you will be provided with a series of words. Your task will be to write a word that you think each provided word is an example of. That is, ask yourself the question, "[Provided word] is an example of what?" and then write down the answer you come up with. For instance, if we gave you the word "POODLE," you might write down "DOGS" or even "ANIMALS," as a poodle is an example of a dog or animal. Be creative and come up with the most general word for which the provided word is an example.

SODA
COMPUTER
NEWSPAPER
PROFESSOR
PASTA
BOOK
SPORT
TABLE
SHOE
MOVIE
PEN
SENATOR
LUNCH
TRAIN
MAIL
ACTOR
BEER
PHONE
SOAP
FRUIT

COIN
RESTAURANT
TREE
GAME
PAINTING
BAG
WATER
COLLEGE
DANCE
CANDY
GUITAR
MOUNTAIN
POSTER
SOAP OPERA
RIVER
MATH
KING
WHALE
SINGER
TRUCK

APPENDIX H

Debriefing Script

Debriefing Script

Thank you for taking part in this investigation. I realize that performing the endurance exercise task may have been challenging for you. Although you were told that after 10 minutes of exercise sufficient data was collected, the amount of persistence after the 10 minute mark may be used as a measure of how much self-control you exerted on the task. Because we wanted to see how much exercise you were willing to do without any input from me, we did not make you aware of this aspect of the study beforehand. Because you were unaware of this aspect of the procedure when you first consented to participate in the study, I need to advise you that you may choose to withdraw from the study and your data will not be used. If you choose to withdraw now, you will still be compensated for your participation in the study. However if you choose to have your data included, I would ask that re-consent to participation in the study at this time by signing below.

Please sign below

____

In the current literature, there is a theory that suggests certain mindsets can increase physical performance and self-control on subsequent tasks. In this study we are comparing the physical performance of individuals induced into either an abstract (bigger picture and more general thoughts) vs. a concrete (more specific and detail-oriented) mindset. In addition, we were also investigating how adding a cognitively demanding task (the Stroop Task) might affect their performance.

We are also investigating the applicability of this theory in a more practical setting- particularly in a cycling exercise task.

We do not know how the results of the study will work out until we have analyzed the data. If you are interested in receiving an executive summary of the findings, please provide a contact email address on the sheet where you sign for having received your honorarium for the study and we will send it to you when it is available.