THE EFFECTS OF LISTENING TO PREFERRED MUSIC ON POSITIVE EMOTIONS AND SELF-REGULATORY STRENGTH DEPLETION PATTERNS USING ISOMETRIC HANDGRIP EXERCISE.

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Abstract

Self-regulation refers to the ability to override one behaviour, thought, or emotion and replace it with another (Baumeister & Heatherton, 1996). Baumeister et al. (1998) propose that self-regulation is governed by a form of strength that varies from person to person and can be depleted by engaging in tasks that require self-regulation. Although self-regulation strength can be depleted, it may also be replenished through rest and other hypothesized mechanisms. Positive emotion has been suggested as a way to replenish depleted self-regulatory reserves (Tice et al., 2007). The purpose of the current study was to investigate the effects of listening to self-selected uplifting music on positive emotional states and the effect of varying positive emotional states on self-regulatory strength depletion patterns. It was hypothesized that the group that listened to a selection of preferred music would show an increase in positive emotion on the PANAS measure and that the positive emotion induction would serve as a replenishment of self-regulation, which would lead to amelioration of depletion effects on a handgrip squeezing exercise performed after this induction. The study employed a between subjects, repeated measures design. Participants were 90 sedentary university students ($M_{age} = 22.90 \pm 7.18$) who were randomly assigned to one of three conditions; (Stroop) Depletion/Music (emotion induction), Depletion/No Music (quiet rest control), or No Depletion/No Music (no depletion control and quiet rest control). After controlling for initial positive emotion scores, ANOVA results revealed that participants showed significantly higher scores on the positive emotion scale of the PANAS, $F(2,87) = 7.84$, $p < .01$. $\eta^2 = .73$ after listening

to music than engaging in quiet rest. The results further illustrate that the change from pre- to post- manipulation in raw mean scores for each condition did not differ significantly in the length of time that participants held onto the handgrip during the endurance trial at 50% MVC, $F(2,87) = 0.30$, $p = .74$, $\eta^2 = .01$. After 18 participants were eliminated due to questionably low (≤ 5) RPE ratings on the pre-test, the ANOVA was completed again, and no significant differences emerged, $F(2,68) = .68$, $p = .51$, $\eta^2 = .02$. Although the results do not demonstrate that positive emotion has an impact on self-regulatory strength depletion patterns, the current findings are discussed with respect to previous research done by Tice et al. (2007) and in light of Fredrickson's broaden and build theory and limitations. Further research is warranted to gain a better understanding of the relationship between music, positive emotion and self-regulation for exercise.

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Introduction and Literature Review

An overweight dieter binges on chocolate cake after caring for her sick and crying baby through the night.

A recovering alcoholic drinks a shot of whiskey following his best friend's wake.

A parolee provokes a fight on the subway after being turned down for a job.

Following an argument with his spouse, a heart attack survivor skips his exercise rehabilitation session to have a cigar and watch a rerun of "Cheers" from his couch.

Each of these examples illustrates a behaviour the enactor might desperately want to avoid, yet s/he engages in it anyway. Each example illustrates a failure of self-regulation linked to an emotional experience.

Self-regulation refers to the ability to override one behaviour, thought, or emotion and replace it with another (Baumeister & Heatherton, 1996). Self-regulation research has a long tradition in psychology (Baumeister & Heatherton, 1996) and theories of self-regulation have developed from numerous perspectives (Baumeister & Vohs, 2004). While some theories have received more empirical attention than others, not one is considered definitive; however most share common or similar conceptual components (Baumeister & Heatherton, 1996; Baumeister & Vohs, 2007). According to Baumeister & Vohs (2007), most theories of self-regulation include four constituent ingredients: (a) standards, (b) monitoring, (c) strength, and (d) motivation. Each of these components contribute to successful self-regulation. Having a standard or goal is necessary to have a quantifiable direction and level at which to aim one's thoughts, behaviors, or emotions. If someone is going to be successful in the self-regulation of exercise, for example, s/he should set a standard of what, when and how s/he will do in the performance of that behaviour. The second component of successful self-regulation is monitoring, where a person directs attention to keep track of his/her thoughts, behaviours, or emotions. Monitoring is thought to work in concert with standards as people may self-regulate more effectively when they monitor themselves in relation to their standard.

The strength of one's self-regulatory capacity also contributes towards effective self-regulation. Baumeister and colleagues propose that self-regulatory strength is a limited capacity that varies from person to person and can be depleted by engaging in self-regulatory tasks. The fourth component of self-regulation is motivation. Motivation represents one's ambition or drive to successfully self-regulate. All four of these components make dynamic, complementary, and compensatory contributions to self-regulation. That is, each component can change during self-regulatory processes, help stimulate activation of other components, and make up for shortfalls in other components. On the other hand, however, when one or more components is lacking, self-regulatory failures are more likely to occur (Baumeister & Vohs, 2007). The focus of this thesis is on the third component – self-regulation strength.

Limited Strength Model of Self-regulation

The concept representing the strength component of self-regulation is similar to the colloquial concept of willpower and has been developed by Baumeister, Bratslavsky, Muraven & Tice (1998). Currently, the representation of self-regulatory strength is hypothetical (i.e., there is no directly observable or measureable strength reserve), so the theoretical basis of the model is framed in terms of several assumptions (Baumeister et al., 1998): (1) people have a limited resource that governs the ability to execute self-regulatory operations, (2) acts of self-regulation consume the limited resource resulting in temporary depletion, (3) when the resource is depleted, self-regulation of other tasks is impaired, (4) self-regulatory operations, whether they involve cognitive, behavioural, or emotional control all draw on the same resource, (5) the self begins to alter its responses before the resource is fully depleted, (6) the resource can be replenished through rest and possibly other mechanisms.

Self-regulation Strength Depletion: The Evidence

The limited strength model has generated a considerable body of supportive evidence from over 50 published reports (Gailliot & Baumeister, 2007). A variety of tasks have been used to examine processes and characteristics of self-regulatory strength depletion. In one of the earliest investigations of the limited strength model, Muraven, Tice & Baumeister (1998) performed a series of studies observing self-regulatory depletion effects involving a range of tasks requiring self-regulation. In the first study of that series, participants were split into three conditions and were told they were going to be watching a movie. Participants in the first condition were asked to "really get into the movie" and amplify their emotions and facial expressions in response to the video content. Participants in the second condition were told the opposite, and given instructions to suppress their emotional responses to the video content and make no facial expressions that may reflect the way they feel while watching. Participants in the third condition (controls) were given no instructions regarding emotion regulation and simply watched the movie. The emotion regulation (both suppression and amplification) conditions were expected to deplete self-regulatory strength. Following the movie watching, all participants engaged in a handgrip squeezing endurance task which required further self-regulation. Results showed that participants in the two conditions requiring self-regulation performed the handgrip squeezing task for a significantly shorter duration compared to the control condition. Furthermore, there were no significant differences in handgrip squeeze times between the two self-regulation strength depletion groups.

The second in the series of studies by Muraven et al. (1998) intended to replicate the findings in the first study using a different set of self-regulation depleting protocols. Participants were again split into three groups, the first group was instructed to try to avoid thinking about a white bear and to write down all thoughts that came to mind, the second group was instructed to do the opposite, to think about a white bear as much as they wanted and write down all their thoughts, and the third condition was given no specific instructions regarding what to think about, and to write down their thoughts. In this study, the thought suppression task was expected to deplete self-regulation strength and latter two conditions served as controls. All groups carried out their tasks for 6 minutes. Following this procedure, participants were given instructions on how to solve anagrams. They were then left alone to work on a list of anagrams which were actually unsolvable and told that when they were finished, or wanted to stop, they could ring a bell that would end the exercise. Results showed that participants in the thought suppression (do not think about a white bear) condition persisted on the unsolvable anagrams for a significantly shorter duration than the two control conditions, which did not significantly differ from each other.

The third study in the series by Muraven et al. (1998) involved the same initial self-regulation strength depletion task as Study 2 (suppressing thoughts of a white bear), while a control group was instructed to solve simple math problems (deemed not to be a self-regulatory strength-depleting task). Following this initial task, participants all watched an 18-minute video clip consisting of skits from the comedy television show *Saturday Night Live*, and a standup comedy routine by Robin Williams. All the participants were told to display no reactions of amusement in response to the video and, specifically, to avoid smiling and laughing for the duration of the film clips. The participants were then videotaped while they watched the films and raters counted the number of smiles, bouts of laughter and rated participants' overall displays of amusement. Results showed that participants who engaged in the initial self-regulatory depleting (thought suppression) task exhibited significantly more smiling in response to the humorous video clip, as compared to controls. These results demonstrated a decreased ability to regulate emotions; another display of self-regulatory failure. Thus, in three studies involving cognitive, emotional and physical tasks, Muraven et al. (1998) showed that prior depletion of self-regulation strength interfered with participants' abilities to self-regulate on later tasks.

Self-regulation Strength and Exercise: Is There a Connection?

The handgrip squeezing stamina study by Muraven et al. (1998; Study 1) represents the first study to show the effects of self-regulatory strength depletion on a task involving physical activity. However, it is well known that the behavioural regulation of physical activity causes a number of challenges for people attempting to adhere to exercise programs. For example, over 50% of people who begin an exercise program drop out or cease to exercise regularly within the first six months (Dishman, 1988). Because physical activity requires self-regulation, the limited strength model may have important application to understanding lapses and relapses of exercise behaviour.

Recent studies have used the limited strength model of self-regulation to investigate behavioural regulation of exercise. In a study designed to replicate and extend Muraven et al.'s (1998) findings, Bray, Martin Ginis, Hicks and Woodgate (2008) demonstrated impaired physical stamina on an isometric handgrip task following self-regulatory depletion. Participants in Bray et al.'s (2008) study performed a baseline isometric handgrip squeezing endurance task. Following this task, participants were randomly assigned to either a self-regulatory depletion condition (participants performed a modified Stroop reading task) or a control condition (participants read words printed in matching colour text). Following the reading manipulation, which lasted 3 minutes and 40 seconds, participants performed a second isometric handgrip endurance task. Results showed that performance on the isometric handgrip task was significantly impaired (i.e., shorter endurance) for the group that performed the Stroop task compared to control group. Additionally, their investigation looking at muscle activation in the two groups revealed greater muscle activation in the forearm muscles of depleted participants. Greater muscle activation meant that participants who were depleted of self-regulation strength needed to recruit a significantly greater proportion of muscle motor units to carry out the demands of the isometric handgrip task and thus tired them out more quickly.

Additional support for the application of the limited strength hypothesis to exercise behaviour was seen in a subsequent study by Bray & Martin Ginis (2009), which replicated the results of Bray et al. (2008) using a group of older adults. Likewise, similar findings linking self-regulatory depletion and neuromuscular fatigue were seen in a study by Clayton (2008) who examined the effects of self-regulatory depletion on performance of an isometric ankle dorsiflexion task. In this study, participants performed a baseline isometric ankle dorsiflexion stamina task after which they performed a Stroop task to deplete them of self-regulation strength. Results showed that participants displayed greater declines in endurance on the second isometric ankle dorsiflexion task compared to the non-depleted control group. Collectively, these studies further generalize the limited strength hypothesis to older adults and physical tasks other than handgrip squeezing. Therefore, evidence supports the limited strength hypothesis that when a person is depleted of self-regulation strength due to performance of a cognitively demanding task, it affects subsequent performance of isometric exercise tasks requiring muscular stamina.

While isometric exercise tasks have some application to understanding how self-regulation strength depletion can interfere with exercise performance, a recent study by Martin Ginis & Bray (in press) extended the investigation of self-regulation depletion to tasks requiring cardiovascular effort as well as intentions or plans for exercise. In that study, all participants performed a baseline cycling exercise for 10 minutes at a rating of perceived exertion (RPE) level of 5, during which their work output (measured in kJ) and heart rate (in beats per minute; bpm) were recorded. Participants were then asked to plan a post-study exercise session in which they selected a series of exercises they would perform based on the perceived effort (RPE) required by each exercise. Participants were then randomly assigned to either a self-regulatory depletion condition (modified Stroop task) or a control (non-depletion) condition which lasted for 3 minutes and 40 seconds. Following the manipulation, participants were asked to reformulate their exercise circuit selections for post-study session and cycled again for 10 min at an RPE of 5. Results showed that participants in the self-regulation depletion condition cycled at a lower workload compared to the controls. The depleted group also chose to exert significantly less effort toward the upcoming exercise circuit after depletion compared to the controls. These findings illustrate that self-regulation depletion can have negative effects on cardiovascular performance as well as motivation to invest effort in physical activities.

In summary, a considerable body of literature shows that when people engage in one task requiring self-regulation, they show deficits in their performance of physical activity tasks requiring self-regulatory strength later on. Given the importance of self-regulation for exercise adherence and the evidence showing the negative effects of self-regulation strength depletion for the performance of physical activity tasks, research that could uncover ways in which self-regulation strength can be enhanced should have important implications for exercise psychology.

Modifying Self-Regulation Strength

As noted above, the limited strength model of self-regulation currently encompasses several (i.e., 6) assumptions. However, the majority of the research evidence has been garnered through examination of processes involved in the first five assumptions, while the sixth – that the self-regulatory strength resource can be replenished through rest and possibly other mechanisms—has received less attention.

In one of the few studies to have examined this assumption, Muraven, Baumeister & Tice (1999) had people engage in a self-regulatory training intervention based on the premise that, like muscular strength, self-regulatory strength should increase with repetitive practice. In that study, participants first performed a baseline measure of handgrip endurance and after completing a depleting thought-suppression task, showed the expected decrements in their handgrip stamina. Following that initial phase of the study, half the participants were instructed to engage regularly in one of three exercises, each involving self-regulation; improving posture when slouched, tracking food consumed, or regulating mood for a period of two weeks, while the other half received no such instructions. When they returned to the laboratory two weeks later, participants who had performed the self-regulation strength training tasks showed longer handgrip endurance after performing a thought-suppression task compared to the control group.

A similar study looking to extend these results by using a training period of longer duration and multiple self-regulatory indicators was carried out by Oaten and Cheng (2006). In this study, participants performed a visual tracking task before and after a depleting thought-suppression task and the number of performance errors was recorded in each condition. They were then assigned to a physical exercise training group or a wait list control group and were tested again at monthly intervals. Results showed that participants involved in the exercise training group demonstrated significant improvements on the visual tracking task by making fewer errors at each monthly time point, while people in the control group showed no differences in their visual tracking performance over time. Thus, training appeared to increase self-regulation strength in this study as well. Together, these studies show that self-regulatory strength can be developed through systematic training.

While the self-regulatory capacity may be developed by training, another possible way of enhancing strength or overcoming deleterious effects of depletion might be through intervening at, or shortly after, the time that self-regulatory strength reserves are being diminished. Results of a series of studies by Gailliot and colleagues (2007), supports this possibility. Gailliot et al. (2007) proposed that because self-regulatory processes underlying volitional behaviours occur at the level of the brain and that all of the brain's functions are fueled by glucose metabolism, the extent of self-regulatory strength depletion should correlate with blood glucose concentration and that glucose supplementation should ameliorate the effects of self-regulatory depletion. Consistent with these propositions, Gailliot et al. (2007) demonstrated that blood glucose levels were indeed depleted following the performance of emotional and cognitive tasks requiring self-regulatory strength (Studies 1 and 2). Furthermore, they showed that when participants were given a drink enriched with glucose, they performed better at a subsequent self-regulation task than people who were given a placebo drink containing only artificial sweetener (Studies 7, 8 and 9).

Investigation of methods that allow one to overcome acute self-regulatory depletion has also involved the manipulation of emotional states. Tice, Baumeister, Shmueli & Muraven (2007) carried out a series of studies in which they had participants perform either a preliminary self-regulatory strength depleting act or a control task, then participants were exposed to a variety of emotion induction manipulations, which, in turn, affected their self-regulatory strength on a subsequent act requiring self-regulation strength. In the first study in this series, participants were randomly assigned to either a self-regulatory strength depletion condition or a control group. Participants in the depletion condition performed the thought suppression task used by Muraven et al. (1998), where participants had to write down their thoughts for 5 minutes while trying not to think of a white bear, while the controls were free to express any thoughts that came to mind. Directly following the depletion or control manipulation, the experimenter offered half the participants a surprise gift of candy to induce positive emotion and the rest were offered a receipt for participating in the study (neutral emotion induction condition). Participants were then asked to self-regulate by consuming as much as they could of a foul tasting, but healthy drink. Results demonstrated that the participants who were depleted of self-regulation by the thought suppression task and then induced into a positive emotional state drank just as much of the drink as the control group that did not perform the thought suppression task at the outset of the study. Participants in that condition also drank significantly more than those who performed the thought suppression task and were induced into a neutral emotional state.

The second study had participants randomly assigned to either a condition which performed a task that caused self-regulatory depletion or a control condition. One half of the participants in the depletion condition were then induced into a positive emotional state by having them view a comedy video clip. The other half of the participants in the depletion condition and those in a control (non-depleted) group were induced into a neutral emotional state by viewing a dolphin communication video clip. Then all participants performed a subsequent self-regulation task requiring physical co-ordination in which metal rods were manipulated in attempt to guide a ball up a track into a goal. The game, however, was engineered to malfunction and therefore the task was very difficult and frustrating. The amount of time participants spent persisting at playing the game served as the dependent variable. Results showed participants who were depleted of self-regulation strength and then induced into a positive emotional state persisted significantly longer at the game than those who were depleted and then induced into a neutral emotional state. Participants in the positive emotion manipulation condition also did not differ significantly from those who performed the non-depleting control task earlier on.

The third study in the series replicated the findings of the first two using a different outcome variable, this time a handgrip squeezing stamina task. Participants performed a baseline measure of handgrip stamina, in which they held a wad of paper between the handles of a spring loaded handgrip squeezing device. All participants were then depleted of self-regulation strength using the thought suppression task from Study 1. Next, participants were randomly assigned to either a positive, neutral or sad emotion manipulation condition in which they watched a 5-minute video clip designed to induce the desired emotional states. Participants then performed the handgrip stamina task again and the difference in the amount of time they held the squeeze compared to the first trial served as the dependent variable. Results showed that participants who were induced into the positive emotional state after depletion showed no significant change in handgrip performance compared to their baseline scores, whereas the neutral and sad emotion conditions showed significant declines in handgrip endurance on the second handgrip stamina task.

The last study by Tice et al. (2007) required all participants to refrain from eating for at least 3 hours prior to their study appointment in order to induce a state of hunger. At the start of the study, they were brought into a lab that had an aroma of freshly baked cookies and were presented with a plate filled with both cookies and candies and a bowl of radishes. All participants were told they were in a "radish tasting" condition for this study, and were left alone in the room with instructions not to eat any cookies or candy, but they should eat at least one radish or as many as they desired. Having people resist the temptation to eat the cookies or candy served as the self-regulation strength depletion task. Participants were then randomly assigned to be induced into either a positive or neutral emotional state by watching a comedy video or a dolphin communication video, respectively. The dependent variable in this study was the time spent persisting at an unsolvable figure tracing puzzle that was given to the participants after the emotion induction manipulation. The results of this study supported the findings of the first three studies showing that participants who watched the comedy video persisted for a significantly longer time on the unsolvable puzzle task than did those in the neutral condition.

Collectively, the results of these studies show that inducing a state of positive emotion can counteract the self-regulatory strength depletion effects that are generally seen in other studies (e.g., Baumeister et al., 1998). Importantly, and with specific respect to tasks requiring physical stamina, in Study 3, Tice et al. (2007) illustrated the potential for positive emotional states to modify self-regulation strength depletion effects that have been seen in studies of isometric handgrip endurance (Bray et al., 2008; Bray & Martin Ginis, 2009; Muraven et al., 1998). Thus, positive emotional states may have important implications self-regulation and therefore may aid in the understanding of exercise adherence behaviours and for interventions attempting to increase exercise adherence. The focus of the present thesis is to examine the effect of positive emotional states on patterns of self-regulatory strength depletion involving an exercise task.

How do Positive Emotional States Affect Self-Regulatory Strength?

Tice et al. (2007) have potently illustrated the potential for positive emotional states to modify the effects of self-regulation strength depletion across a variety of tasks requiring self-regulation strength. Several lines of convergent theorizing and empirical data can account for these effects. According to Fredrickson (1998) the experience of positive emotion allows a person to interpret their current circumstances as desirable, which results in an increased likelihood to "broaden and build." By "broaden and build," Fredrickson means that when people experience a positive emotional state, their scope of attention and the range of thoughts leading to action are broadened. From this broadened state, they can build the necessary internal resources to manage effectively in challenging situations.

Fredrickson's broaden and build theory highlights a number of abstract processes that may be enhanced when people experience positive emotion. However, it fails to specify neurophysiological mechanisms that could serve to translate positive emotional states into behavioural response patterns that would differ from those present under less positive emotional states. Research and theorizing from behavioural neuroscience offers complementary information that bolsters the hypothesis that positive emotion may assist in self-regulation. One way in which positive emotional experiences can affect behaviour is via increased dopamine activation in the prefrontal cortex (PFC) and anterior cingulate cortex (ACC) (Phillips, Bull, Adams & Fraser, 2002).

The ACC and PFC have been identified as key structures in the central nervous system that govern regulation of emotion, social cognition, executive function and feelings of control (Banfield et al., 2004; Declerck, Boone, & De Brabander, 2006). Empirical support comes from brain imaging studies that examine cortical activity during performance of tasks that are commonly used in self-regulatory strength depletion studies. One study (Liu, Shan, Zhang, Sahgal, Brown et al. 2003) looked at functional magnetic resonance imaging (fMRI) scans of participants performing a submaximal handgrip fatigue task. The results showed high activation in the PFC during the isometric handgrip contraction, with progressively greater activation of the PFC over the course of a prolonged fatigue trial. Indeed, activation of the PFC was much higher compared to other brain structures such as the supplementary motor area and the cerebellum, suggesting the PFC plays an important role in maintaining a submaximal handgrip squeeze over time. Additional studies have demonstrated increased PFC and ACC activation in participants engaging in a difficult puzzle solving task (Mai, Luo, Wu, & Luo, 2004), a thought suppression task (Wyland, Kelley, Macrae, Gordon, & Heatherton,

2003) and the Stroop colour-word task (Phillips et al. 2002) – all tasks that have been used to manipulate or determine self-regulation strength.

Although studies suggest the PFC and ACC are key structures involved in self-regulation, they do not provide a direct indication of how positive emotional states may assist people in self-regulation. However, activation of the dopaminergic system that occurs during positive emotional states may play an important role in this process. Dopamine (DA) is a neurotransmitter that is widely dispersed throughout the brain, and though DA neurons comprise less than 1% of the brain's neurons, they are integral to proper functioning of the brain (cf. Arias-Carrion & Poppel, 2007). DA is implicated in motivation, reward, learning, memory, attention and emotion-related behavior (Arias-Carrion & Poppel, 2007). Neuroimaging studies have demonstrated that when a person experiences positive emotion, there are increases in DA metabolic activity and increases in DA levels in the brain (Burgdorf & Panksepp, 2006). Declerck et al. suggest that self control may be a function of cortical dopamine activation, particularly in the ACC and the PFC and that dopamine activation appears to encourage focused attention, monitoring of actions and decisions regarding behavior. Therefore, dopaminergic activity in the ACC and PFC may underlie the broaden and build theory processes described by Fredrickson (1998). Taken in concert, the broaden and build perspective, dopamine evidence and collateral support in evidence from studies done by Tice et al. (2007) support the role of positive emotional states in enhancing self-regulation.

Manipulating Positive Emotional States

Many emotion induction procedures have been used in previous literature to induce positive emotional states (Westermann, Spies, Stahl & Hesse, 1996). For example, films, stories, imagination, facial expressions, social interaction, feedback, gifts and music have all been used heighten people's positive emotions (Westermann et al.). It was noted earlier that Tice et al. (2007) were successful in inducing positive emotion using comedy video clips. The current study sought to expand upon the literature examining replenishment of self-regulation through positive emotion by examining the effects of listening to music.

It is common for individuals to enjoy listening to music while engaging in many daily activities that require self-regulation such as performing repetitive work tasks and exercising. Indeed, the use of personal music listening devices (iPod, mp3 players) is commonplace in the realm of exercise. For example, it is not unusual to see people running or walking outside listening to personal music playing devices. As poor self-regulation may contribute to a lack of regular exercise, it is possible that individuals may choose to listen to self-selected music when exercising in order to manipulate their mood into a more positive emotional state, whereby effective self-regulation may take place. This is the first known study to explore music as a positive emotion induction procedure following self-regulatory depletion. This thesis proposes to extend research examining the effects of positive emotional states on self-regulatory depletion patterns by looking first at emotional reactions to music.

Music and Emotion

Music has been long understood to have properties that elicit a variety of emotional reactions (Zentner, Grandjean & Scherer, 2008). Emotions are defined as brief responses to changes in the environment, and they feature a number of sub-components such as cognitive appraisals, subjective feelings and physiological responses (cf. Juslin & Sloboda, 2001). Anecdotal and empirical evidence indicate that listening to music is a common method people use to manipulate their emotional states. In an illustrative study showing how music is integrated with emotional experiences, Juslin, Lilestrom, Vastfjall, Barradas, & Silva (2008) used experience sampling methods (ESM) in which personal electronic palmtop devices which were activated at 7 random intervals throughout the day over a period of two weeks. Each time participants heard the sound signal coming from the device, they were instructed to complete a questionnaire about their emotional state their experiences with music at the time. The results showed that at 37% of the signaled time points, the participants were involved at some level with music (e.g., listening to music, playing music, singing), and during 64% of those "music times", the participants reported the music they were listening to influenced how they were feeling. Positive emotions were more likely to be present during the "music times," and emotions were felt with greater directionality (i.e., positive or negative) and intensity when paired with "music time" points.

Musical Preference

Music mood induction procedures (MMIPs) have been shown to be effective in previous research looking at emotion (Willner & Jones, 1996; Westermann et al. 1996). A review by Martin (1990) that evaluated the effectiveness of mood induction methods suggests that music induces the intended mood successfully 75% or more of the time. However, simply having people listen to music may not be a sufficient means of manipulating emotions. Furthermore, although music can effect emotion, not all music can be expected to have the same effect for all people; as the same piece of music might stimulate positive emotion for one individual, negative emotion for another, and have little emotional effect on others.

In terms of purposefully eliciting a positive emotional response, there is evidence to suggest people can identify specific pieces of music they use for this purpose (Bull, 2005). In a study by Juslin et al. (2008), music tended to be associated with evoking more emotion when it was familiar to participants. Because of the heightened positive response that occurs with exposure to self-selected music, allowing people to select preferred music to listen to appears to be an important consideration for manipulating emotional states.

Music and Self-Regulation

Music has not been looked at in terms of manipulating positive emotions in order to overcome the effects of self-regulation strength depletion. However, listening to music is a stimulus that is commonly used to purposely regulate or manipulate emotions (Bull, 2005; Thayer, Newman & McClain, 1994). Indeed, numerous studies identify listening to music as being among the most common strategies for regulating emotions (e.g., energizing oneself, getting out of a bad mood) among adolescents and young adults (Christenson & Roberts, 1998; Saarikallio & Erkkilä, 2007; Sloboda & O'Neill, 2001; Wells & Hakanen, 1991). Other studies point to the psychogenic effects of music.

Hayakawa and Miki (2000) found that participants reported less fatigue during a bout of aerobic dance when music was played concurrently, compared to a no-music condition. A study by Browning (2000) also showed listening to music to be effective in pain management and reducing perceptions of pain among women who were in labour during childbirth. Although none of these studies conceptualized behavioural, cognitive or emotional effects linked to music exposure in terms of self-regulatory processes, both aerobic exercise and pain management involve self-regulation. Thus, there is some preliminary empirical evidence that points to music exposure and its potential to affect self-regulation of emotion, cognition and action.

Purpose of the Current Study

The purpose of the current study was to investigate the effects of listening to self-selected uplifting music on positive emotional states and the effect of varying positive emotional states on self-regulatory strength depletion patterns.

Hypotheses

Based on music and emotion literature, two hypotheses were proposed.

Hypothesis 1i. It was predicted that participants would show an increase in positive emotional state after listening to a preferred music selection.

Hypothesis 1ii. It was predicted that participants who listened to their preferred music selection would report higher positive emotion scores than those who experienced quiet rest (controls).

Furthermore, based on previous self-regulation strength depletion studies, Frederickson's broaden and build theory, and the evidence for the dopamine-self-regulation connection, three additional hypotheses were proposed.

Hypothesis 2i. Based on previous studies of self-regulation strength depletion and physical stamina, it was predicted that participants who performed a modified Stroop task would show greater self-regulatory strength depletion effects compared to a control group that performed a coloured-word reading control task.

Hypothesis 2ii. It was predicted that participants who listened to a selection of preferred music would show decreased self-regulatory strength depletion effects following performance of a modified Stroop task compared to a control group that experienced only quiet rest following performance of a modified Stroop task.

Hypothesis 2iii. It was predicted that participants who listened to a selection of preferred music would show similar self-regulatory strength depletion effects following performance of a modified Stroop task compared to a control group that performed a non-depleting coloured-word reading control task.

Method

Participants and Recruitment

Participants in the study included 90 university students (26 males and 64 females) who reported engaging fewer than two weekly sessions of leisure time physical activity during the prior 6 months. The sample consisted of graduate and undergraduate students and had a mean age of 22.9 (*SD* =7.2) years. Participants were recruited via a website advertisement on the University homepage and posters placed in several buildings on the McMaster University campus. Additionally, announcements were made in classrooms where students could volunteer their contact information to schedule appointments for participation. The McMaster research ethics board (MREB) approved the protocol prior to any recruitment or collection of data for the study and all participants completed informed consent prior to taking part in the study.

Measures and Manipulations

Demographics. Participants provided demographic information regarding their age, year of study at university, marital status, ethnicity, and gender. All participants were screened to ensure they had physical activity levels which were less than twice per week on average over the previous 6 months (Godin, 1985). Additionally, the participants completed the PAR-Q (2002), which provided an indication they had no medical contraindications limiting participation in the isometric handgrip exercise task.

Musical preference elicitation questionnaire. Participants completed a questionnaire that involved naming their favourite song, their favourite artist, their top three favourite most uplifting songs, and their least favourite song. They were also asked whether or not they considered themselves to be a musical person.

Ratings of perceived exertion (RPE). Individuals' ratings of perceived exertion (RPE) were measured to assess how much exertion they put forth during the maximum handgrip squeezes (MVCs) and submaximal handgrip endurance trials. It was important to understand whether they had worked as hard as they could during the endurance trials to achieve a maximum fatigue level. For each rating, participants were shown Borg's (1998) 10-point CR-10 scale and instructed regarding the scaling of the measure. Participants were rated their exertion levels immediately following each MVC and endurance trial using Borg's (1998) 10-point CR-10 scale.

Isometric handgrip task. The dependent variable in this study was the change in the participants' endurance time for holding a 50% maximum voluntary contraction (MVC) on an isometric handgrip task. Prior to the testing of the 50% MVC endurance trials, the participants engaged in two maximal isometric handgrip trials, each lasting 5 sec. The mean force produced by participants during the two MVC test trials served as the basis for establishing the criterion force value for the 50% MVC endurance trial (i.e., 50% of maximum mean force generated during MVC). For the endurance trials, participants were instructed to squeeze the handgrip at or above the 50% MVC level for as long as they could. They knew they were at the appropriate level based on feedback they received via a 17"computer monitor set up in front of them. They were told that if the line on the screen displaying their force generation value dropped below the target line on the screen for more than a few squares on the screen (gridlines translating to .75 seconds), then the trial would be terminated and their endurance time would be recorded.

Self-regulatory strength depletion manipulation. The modified Stroop colour-word task was used to deplete self-regulatory strength. The Stroop task has been shown to be a valid method of depleting self-regulatory strength in studies by Bray et al. (2008), Bray & Martin Ginis (2009) and Martin Ginis & Bray (in press). This task consisted of reading lists of colour words (blue, green, red, etc.) that were printed in ink colours that were incongruent with the colour represented by the word. For example, the word "blue" was printed with green ink. The participants were instructed to read out loud the ink colour of the words and not the words themselves (e.g., the word "blue" printed in green ink requires one to respond by saying aloud the word "green"). This task requires self-regulatory strength in order to override the natural tendency to read the written word. The task was made more depleting by having participants also treat words printed in red ink differently. That is, when they encountered a word printed in red ink, they were instructed to override the first rule and read aloud the word as they saw it written (e.g., the word "blue" printed in red ink requires one to respond by saying aloud the word "blue"). The Stroop task was performed for 5 minutes. Two groups performed the Stroop task using the incongruent word/ink protocol, while a third group, the control condition, performed a similar task in which the words representing colours were written in an ink colour congruent with the word (e.g., the word "blue" was written in blue ink). This task does not require self-regulation and does not result in self-control depletion effects (Bray et al., 2008).

Positive emotion induction manipulation. Participants assigned to the music condition (positive emotion induction) listened to a 2-minute clip from their favourite uplifting song. The first choice listed for their favourite most uplifting song (taken from the music preference elicitation task) was downloaded on a laptop from iTunes or YouTube and played for them for 2 minutes. Listening to music served as the positive emotion induction for the music replenishment condition.

Manipulation check measures. A series of manipulation check items (Bray et al., 2008; Muraven et al., 1998) were used to gauge participants' levels of fatigue, effort, frustration and pleasantness after performing the Stroop colour word task (depletion paradigm); (a) How fatigued are you after performing the word task? (1 = *not at all tired* to 7 = *extremely tired*), (b) How much mental effort did you exert during the word task? (1 = *little effort* to 7 = *extreme effort*), (c) How frustrated did you feel while doing the word task? (1 = *not at all frustrated* to 7 = *extremely frustrated*) and (d) How pleasant was the word task? (1 = *extremely unpleasant* to 7 = *extremely pleasant*). Responses were recorded on a 7-point Likert scale.

Emotional states. To measure emotional states before and after the music induction procedure and verify the positive emotion manipulation, the Positive and Negative Affect Schedule (PANAS; Watson et al. 1988) was administered to participants. The PANAS consists of two, 10-item subscales that measure positive and negative emotion. The scales have been used to ask participants how they feel "at this moment" and they have alpha reliabilities of .89 and .85, respectively, when used for this purpose.

In the present study, the positive affect scale had an alpha reliability (Cronbach's α) of .89 and the negative affect scale had an alpha reliability (Cronbach's α) of .75.

Procedure

The chronological steps involved in the procedure are outlined in Figure 1. Participants were screened based on the inclusion criteria. Upon each participant's arrival at the lab, informed consent and demographic measures were obtained. As part of the demographic measures, each participant completed the musical preference elicitation questionnaire. After filling out the demographic survey, participants performed a single maximum voluntary contraction (MVC) of the handgrip task for a 5-sec duration. They were then asked to rate their perceived exertion according to the Borg (1998) 10-point CR-10 scale for rating of perceived exertion (RPE). A second MVC was then performed after a 30 sec rest and the mean of the two were used to calculate the 50% MVC level for the endurance trial to follow. RPE for the second MVC was also rated by participants. Prior to the first endurance trial, participants completed a 10-sec practice trial to experience the task demands and confirm their understanding of the endurance task (i.e., maintaining a hand squeeze with adequate force). Each participant was told to hold their handgrip squeeze hard enough that the red line (force reading feedback) stayed above the blue criterion line on a computer monitor that was placed in front of them. A two-min rest preceded the baseline endurance trial. The first endurance trial (Trial 1) was then performed where the participants were instructed exactly as in practice, but were told this time to continue to hold the force reading above the criterion line for as long as they could. They were told that once their force reading dropped below the 50% line on the screen for more than 3 squares (.75 sec) the trial would be over.

Immediately after the first handgrip endurance trial, participants completed RPE ratings and were randomly assigned to one of three experimental conditions. Participants in two groups performed the modified Stroop task while the other condition performed the word reading control task. All groups performed these tasks for 5 min. Following the 5-minute Stroop (or reading control) task, all participants completed the manipulation check questionnaire and the baseline measure of the PANAS. Then, participants assigned to the positive music condition listened to music for 2 min, while participants in the other two groups rested quietly for 2 min. The PANAS was then administered again after the 2-min rest or music-listening period.

Following completion of the second PANAS measure, each participant performed the second 50% MVC endurance handgrip trial (Trial 2). When the second endurance trial was over (the participant held the 50% MVC handgrip squeeze for as long as they could), they completed a final RPE rating. At that point, participants were told that the experiment was over. Each participant was then de-briefed and remunerated a sum of $15.

Data Analysis Strategy

To test hypothesis 1i., a within subjects ANOVA was computed to compare PANAS positive emotion ratings before and after the emotion induction procedure. Hypothesis 1ii. was tested using analysis of covariance (ANCOVA) to control for the initial PANAS positive scores, and evaluate whether the emotion induction was effective between groups. Tukey's post hoc tests were used to identify the direction of significantly different results revealed by the ANCOVA.

The second set of hypotheses was evaluated by looking at both raw scores and residualized change scores. Because the amount of change in handgrip squeeze persistence between trials is usually highly correlated with scores on the first trial (Bray et al., 2008), residualized change scores help control for the effect of Trial 1 handgrip endurance scores handgrip endurance change scores. One-way ANOVAs were used to analyze differences in change scores between groups from Trial 1 to Trial 2. Significant ANOVA results were followed up with planned contrasts to evaluate differences in mean change scores between study conditions.

Conditon 1: Stroop Depletion and Music Manipulation	Conditon 2: Stroop Depletion and No Music Manipulation	Conditon 3: No Stroop Depletion and No Music Manipulation
Informed Consent Demographics Music Preference	Informed Consent Demographics Music Preference	Informed Consent Demographics Music Preference
MVC1	MVC1	MVC1
RPE	RPE	RPE
MVC2	MVC2	MVC2
RPE	RPE	RPE
Fatigue Trial 1	Fatigue Trial 1	Fatigue Trial 1
RPE	RPE	RPE
Stroop Depletion 5 minutes	Stroop Depletion 5 minutes	Control: Reading Task 5 minutes
Manipulation Check	Manipulation Check	Manipulation Check
PANAS 1	PANAS 1	PANAS 1
Music Manipulation 2 minutes	No Music, Quiet Rest 2 minutes	No Music, Quiet Rest 2 minutes
PANAS 2	PANAS 2	PANAS 2
Fatigue Trial 2	Fatigue Trial 2	Fatigue Trial 2
RPE	RPE	RPE
Debriefing Remuneration	Debriefing Remuneration	Debriefing Remuneration

Figure 1. Schematic timelines of procedures for the three study conditions.

Results

Demographics

The demographic characteristics of the sample are summarized in Table 1. A one-way analysis of variance (ANOVA) was computed comparing the demographics of the three conditions (Depletion/Music, Depletion/No Music and No Depletion/No Music) and showed no significant differences between the groups based on age, $F(2, 87) = 1.36$, $p = .26$. The distributions of men and women across groups was evaluated using a contingency table and were not significantly different, $\chi^2 (2, N = 90) = 1.41, p > .05$.

Manipulation Check

Means and standard deviations of the manipulation check items measuring mental effort, fatigue, frustration and pleasantness are displayed in Table 2. One-way ANOVAs were used to compare the differences among the means and the only significant difference was in the effort measure, $F(2,87) = 24.32, p < .01, \eta^2 = 0.36$. Tukey's post hoc tests showed that there was a significant difference between the Depletion/Music condition and the No Depletion/No Music condition, mean difference = 2.03, $p <.01$ and between the Depletion/No music and No Depletion/No Music conditions, mean difference = 1.53, $p < .01$. Therefore, participants in both conditions that completed the Stroop task reported exerting significantly more mental effort than those who performed the congruent colour word reading control task.

Table 1

Demographic Characteristics of Study Participants

Variable	*N*	*M*	*SD*
Total Participants	90		
Gender			
Male	26		
Female	64		
Age		22.90	7.18

Note: Values for continuous variables are represented by means (*M*) and standard deviations (*SD*). Values for categorical variables are represented as total within the sample.

Table 2

Scores and Effect Sizes for the Depletion Manipulation Check Items (N = 90).

Items	Depletion/ Music *M (SD)*	Depletion/ No Music *M (SD)*	No Depletion/No Music *M (SD)*
Mental Effort	5.80 (.66)$_a$	5.30(.79)$_a$	3.77(1.76)$_b$
Effect Size	*d* = .69	*d* = 1.12	
		d = 1.53	
Fatigue	4.00 (1.76)	3.23 (1.36)	3.13(1.53)
Effect Size	*d* = .49	*d* = .07	
		d = .52	
Frustration	4.07 (1.95)	3.73 (1.68)	3.13(1.66)
Effect Size	*d* = .19	*d* = .36	
		d = .52	
Pleasantness	3.83 (1.34)	3.83 (1.53)	3.53 (1.19)
Effect Size	*d* = 0	*d* = .21	
		d = .24	

Note: Depletion/Music (n = 30), Depletion/No Music (n = 30) and No Depletion/No Music (n = 30). Scores that do not share the same subscript letter are significantly different $p < .01$.

Hypothesis Testing

Hypothesis 1i. Participants will show an increase in positive emotional state after listening to a preferred music selection.

Differences in positive emotional states, as determined by participants' scores on the PANAS, from pre-to post-music manipulation in the music listening condition were evaluated using within-subjects ANOVA. Consistent with the intended purpose of the music manipulation, participants who listened to the music selection reported higher scores on the PANAS positive emotion scale after listening to music compared to before listening, $F(2,28) = 3.75$, $p = .06$, $\eta^2 = .11$. In contrast, participants who did not listen to music showed significant decreases in positive emotion; Depletion/No Music, $F(2,28) = 6.15$, $p = .02$, $\eta^2 = .18$; No Depletion/No Music, $F(2,28) = 8.87$, $p = .01$, $\eta^2 = .23$, following the self-regulation manipulation or control task and the period of quiet rest.

Hypothesis 1ii. Participants who listen to their preferred music selection will report higher positive emotion scores than those who experience quiet rest (controls).

Initial examination of the baseline PANAS scores showed participants in the No Depletion/No Music condition scored lower than the other two conditions on the baseline PANAS positive emotion scale, $F(2,87) = 4.63$, $p = .01$. $\eta^2 = .10$. To control for these differences and assess between group differences on the second PANAS positive emotion ratings, an analysis of covariance (ANCOVA) was performed treating baseline PANAS positive emotion scores as a covariate. Consistent with the intended purpose of the music manipulation, (see Table 3) after controlling for initial positive emotion scores, results revealed that participants in the music listening condition showed significantly higher scores on the positive emotion scale of the PANAS, $F(2,87) = 7.84$, $p < .01$. $\eta^2 = .73$. Tukey's post hoc tests showed significant differences between the Depletion/Music condition and the Depletion/No Music condition, mean difference = 4.20, $p <.05$. Additionally, significant differences were seen between the Depletion/Music condition the No Depletion/No Music control condition, mean difference = 4.27, $p < .01$. In short, participants in the group that listened to their preferred music selection scored higher on the second PANAS positive emotion measure compared to participants in the other two conditions.

Table 3

PANAS Positive Emotion Scores and Effect Sizes Pre- and Post-Manipulation for the Depletion/Music, Depletion/No Music and No Depletion/No Music Conditions across Trials.

	Depletion		No Depletion
	Music	No Music	No Music
	$n = 30$ *M (SD)*	$n = 30$ *M (SD)*	$n = 30$ *M (SD)*
Pre-Manipulation PANAS positive emotion score	31.53 (8.41)	31.23 (7.40)	26.03 (7.76)
Effect Size	Music vs. No Music: $d = .03$; No Music vs. No Depletion/No Music: $d = .69$; Music vs. No Depletion/No Music: $d = .68$		
Post-Manipulation PANAS positive emotion score	33.40 (8.72)	28.90 (9.28)	23.63 (8.32)
Effect Size	Music vs. No Music: $d = .50$; No Music vs. No Depletion/No Music: $d = .60$; Music vs. No Depletion/No Music: $d = 1.15$		
Pre-Post Manipulation Change in PANAS positive emotion score	1.87 (5.28)	-2.33 (5.16)	-2.40 (4.41)
Effect Size	Music vs. No Music: $d = .80$; No Music vs. No Depletion/No Music: $d = .01$; Music vs. No Depletion/No Music: $d = .87$		

Note. *M* = mean, *SD* = standard deviation, *d* = Cohen's effect size. *N* = 90.

Table 4

RPE Values given by Depletion/Music, Depletion/No Music and No Depletion/No Music controls after Handgrip Endurance Trials 1 and 2. Values for Trial 1 and Trial 2 for Full Sample (N = 90) and Sub-sample Scoring ≥ 6 RPE on Trial 1 (n = 72).

	Depletion		No Depletion
	Music	No Music	No Music
	$n = 30$ *M (SD)*	$n = 30$ *M (SD)*	$n = 30$ *M (SD)*
RPE Endurance Trial 1	8.95 (2.41)	8.13 (2.20)	8.57 (2.40)
RPE Endurance Trial 2	9.17 (1.86)	8.27 (2.45)	8.50 (2.40)
	n=24 *M (SD)*	n=24 *M (SD)*	n=24 *M (SD)*
RPE Endurance Trial 1	9.94 (1.37)	8.92 (1.67)	9.54 (1.44)
RPE Endurance Trial 2	9.79 (1.38)	8.92 (1.77)	9.33 (1.79)

Note. $N = 90$ and $n = 72$ reflect full sample and subsamples, respectively. RPE values based on Borg's CR-10 scale of RPE from 1-10.

Hypothesis 2. Preliminary Data Screening.

A primary requirement for examining changes in self-regulation of physical effort in tasks such as the handgrip task is that participants try as hard as they can to perform the task, or, at least, try equivalently hard on both trials. Preliminary analysis of participants' self-reported ratings of perceived exertion (RPE) showed 18 participants rated their exertion on Trial 1 at the mid-point or lower (≤ 5) on the RPE scale, whereas all participants rated their RPE above the mid-point of the RPE scale on Trial 2 (≥ 6). These findings raised concerns that the participants who rated RPE below the mid-point of the scale did not exert a maximal effort on the baseline fatigue trial and therefore did not complete the task as required. Therefore, two sets of analyses were carried out for each of the hypotheses; one with the complete data and the other with only the participants that rated RPE at > 5 on Trial 1.

Hypothesis 2i. The participants that performed a modified Stroop task will show greater self-regulatory strength depletion effects compared to a control group that performed a coloured-word reading control task.

Evaluation of this hypothesis is essentially a test of the self-regulation depletion effect that is typically seen in studies where participants perform an interim self-regulatory strength depletion task between two criterion tasks. The raw scores for handgrip endurance for Trial 1 and Trial 2 as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the complete sample in Table 4. Analysis of the raw change scores revealed no significant differences between groups, $F(2,87) = 0.30$, $p = .74$, $\eta^2 =$

.01. Further analysis of the residualized changes scores, which covaried effects associated with Trial 1 handgrip performance also showed no significant differences between groups, $F(2,87) = 1.36$, $p = .26$, $\eta^2 = .03$.

The raw scores for handgrip endurance for Trial 1 and Trial 2, as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the sub-sample reporting RPE ≥ 6 on Trial 1 are reported in Table 5. Analysis of the raw change scores revealed no significant differences between groups, $F(2,69) = .68$, $p = .51$, $\eta^2 = .02$. Further analysis of the residualized changes scores, which covaried effects associated with Trial 1 performance variations showed significant differences between groups, $F(2,69) = 3.04$, $p = .05$, $\eta^2 = .08$. A planned contrast of the means from the Depletion/No Music and No depletion/No Music groups showed a significant difference, Contrast Estimate = 10.68, $SE = 4.98$, $p = .03$ in the expected direction with the Depletion/No Music condition experiencing greater declines in handgrip endurance (predicted scores) from Trial 1 to Trial 2 compared to the No Depletion/No Music group.

Hypothesis 2ii. The participants that listened to a selection of preferred music will show decreased self-regulatory strength depletion effects following performance of a modified Stroop task compared to a control group that experienced only quiet rest following performance of a modified Stroop task.

The raw scores for handgrip endurance for Trial 1 and Trial 2 as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the complete sample in Table 4. As reported above, analysis of the raw change scores revealed no significant differences between groups, $F(2,87) = 0.30$, $p = .74$, $\eta^2 = .01$. Analysis of the residualized changes scores, which covaried effects associated with Trial 1 performance variations also showed no significant differences between groups, $F(2,87) = 1.36$, $p = .26$, $\eta^2 = .03$.

The raw scores for handgrip endurance for Trial 1 and Trial 2 as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the sub-sample reporting RPE ≥ 6 on Trial 1 are reported in Table 5. Analysis of the raw change scores revealed no significant differences between groups, $F(2,69) = .68$, $p = .51$, $\eta^2 = .02$. Further analysis of the residualized changes scores, which covaried effects associated with Trial 1 performance variations showed a significant difference between groups, $F(2,69) = 3.04$, $p = .05$, $\eta^2 = .08$. A planned contrast of the means from the Depletion/Music and Depletion/No Music groups showed no significant difference; Contrast Estimate = 1.61, $SE = 4.98$, $p = .75$, with essentially equal declines in handgrip endurance (predicted scores) from Trial 1 to Trial 2 in both groups.

Hypothesis 2iii. The participants that listened to a selection of preferred music will show similar self-regulatory strength depletion effects following performance of a modified Stroop task compared to a control group that performed a non-depleting coloured-word reading control task.

The raw scores for handgrip endurance for Trial 1 and Trial 2 as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the complete sample in Table 4. As reported above, analysis of the raw change scores revealed no significant differences between groups, $F(2,87) = 0.30$, $p = .74$, $\eta^2 = .01$. Analysis of the residualized change scores, which covaried effects associated with Trial 1 performance variations also showed no significant differences between groups, $F(2,87) = 0.30$, $p = .74$, $\eta^2 = .01$.

The raw scores for handgrip endurance for Trial 1 and Trial 2 as well as the raw change and residualized change scores representing the differences in endurance time from Trial 1 to Trial 2 are presented, by group, for the sub-sample reporting RPE ≥ 6 on Trial 1 are reported in Table 5. Analysis of the raw change scores revealed no significant differences between groups, $F(2,69) = .68$, $p = .51$, $\eta^2 = .02$. Further analysis of the residualized changes scores, which covaried effects associated with Trial 1 performance variations showed a significant difference between groups, $F(2,69) = 3.04$, $p = .05$, $\eta^2 = .08$. A planned contrast of the means from the Depletion/Music and No depletion/No Music groups showed a non-significant trend; Contrast Estimate = 9.26, $SE = 4.98$, $p = .07$, with the Depletion/Music condition experiencing greater declines in handgrip endurance (predicted scores) from Trial 1 to Trial 2 compared to the No depletion/No Music group.

Table 5

Handgrip Endurance Task Performance Scores and Effect Sizes by Depletion/Music, Depletion/No Music and no Depletion/No Music controls for Trial 1 and 2 for complete sample (N = 90).

	Depletion				No Depletion
	Music		No Music		No Music
	$n = 30$ *M (SD)*		$n = 30$ *M (SD)*		$n = 30$ *M (SD)*
Trial 1 handgrip score (s)	60.43 (35.03)		66.97 (33.48)		70.47 (43.63)
Effect Size		$d = .19$		$d = .09$	
			$d = .25$		
Trial 2 handgrip score (s)	54.70 (21.86)		58.90 (24.44)		67.73 (35.82)
Effect Size		$d = .18$		$d = .29$	
			$d = .44$		
Trial 1 – Trial 2 raw Δ (s)	-5.73 (27.43)		-8.10 (20.78)		-2.74 (31.35)
Effect Size		$d = .10$		$d = .20$	
			$d = .10$		
Trial 1 – Trial 2 residualized Δ (s)	-2.81 (17.83)		-2.08 (15.17)		4.89 (25.49)
Effect Size		$d = .04$		$d = .33$	
			$d = .35$		

Note. Raw Δ = time difference measures as post time to failure – pre time to failure (in seconds). Residualized Δ = estimated time difference adjusted for Trial 1 performance. *M* = mean *SD* = standard deviation. Group values based on $n = 30$ / group.

Table 6

Handgrip Endurance Task Performance Scores and Effect Sizes by Depletion/Music, Depletion/No music and No Depletion/No Music controls for Trial 1 and Trial 2 for Sub-sample Scoring ≥ 6 RPE on Trial 1 (n = 72).

	Depletion		No Depletion
	Music	No Music	No Music
	$n = 24$ *M (SD)*	$n = 24$ *M (SD)*	$n = 24$ *M (SD)*
Trial 1 handgrip score (s)	66.04 (36.78)	63.33 (28.53)	73.00 (40.93)
Effect Size	Music vs. No Music: $d = .08$; Music vs. No Depletion: $d = .18$	No Music vs. No Depletion: $d = .27$	
Trial 2 handgrip score (s)	57.63 (22.30)	54.42 (19.75)	71.00 (35.78)
Effect Size	Music vs. No Music: $d = .15$; Music vs. No Depletion: $d = .45$	No Music vs. No Depletion: $d = .57$	
Trial 1 – Trial 2 raw Δ (s)	-8.41 (14.48)	-8.91 (8.78)	-2.00 (5.15)
Effect Size	Music vs. No Music: $d = .04$; Music vs. No Depletion: $d = .59$	No Music vs. No Depletion: $d = .96$	
Trial 1 – Trial 2 residualized Δ (s)	$-2.87\ (18.74)_a$	$-4.64\ (12.91)_a$	$6.81\ (19.54)_b$
Effect Size	Music vs. No Music: $d = .11$; Music vs. No Depletion: $d = .50$	No Music vs. No Depletion: $d = .69$	

Note. Raw Δ = time difference measured as post time to failure – pre time to failure (in seconds). Residualized Δ = estimated time difference adjusted for Trial 1 performance. *M* = mean *SD* = standard deviation. Group values based on $n = 24$ / group.

Discussion

The purpose of the current study was to investigate the effects of listening to self-selected uplifting music on positive emotional states and the effect of varying positive emotional states on self-regulatory strength depletion patterns. Drawing from an established protocol (Bray et al., 2008), participants engaged in two muscular endurance tasks requiring self-regulation strength that were separated by differential manipulations of self-regulatory strength depletion and emotional states. After the initial endurance task, participants were randomized to one of three groups. Two of the groups were then exposed to another task that was designed to induce further self-regulatory depletion, while the third group performed a control task that did not deplete self-regulatory strength. Following the second task, participants in one of the self-regulation depletion groups listened to a selection of their favourite music, which was intended to increase their positive emotional state, while the other two groups rested quietly. It was hypothesized that the group that listened to a selection of preferred music would show an increase in positive emotion on the PANAS measure. It was also hypothesized that the positive emotion induction would serve as a replenishment of self-regulation which would lead to amelioration of depletion effects that would have otherwise been observed on a handgrip squeezing exercise performed after this induction.

The results of the study partially supported the proposed hypotheses. In support of the first hypothesis, results showed that the participants who listened to music had a significant increase in positive emotional states and scored higher on the positive emotion scale of the PANAS after listening to music compared to groups that rested quietly, both of which experienced decreases in positive emotion. Hypothesis 2i. was also supported as the group that underwent the cognitive (Stroop) depletion task showed a significant negative change in handgrip endurance compared to the No Depletion control group. However, the primary hypotheses of interest; that participants who were induced into a positive emotional state by listening to music after performing the cognitive (Stroop) depletion task would show replenishment of self-regulatory strength on the second handgrip task, was not supported.

The primary research question in this study; examining the effect of positive emotional states on self-regulation performance, was contingent upon a manipulation intended to increase positive emotion. Results showed that participants who listened to music reported greater positive emotion on the PANAS compared to controls and higher scores after listening to a brief selection of their favourite uplifting song compared to their PANAS scores prior to listening to the music selection. Together, these findings supported hypothesis 1 and in their own right contribute to the literature on music and emotion by illustrating the positive effects of listening to preferred music on emotional states. The music and emotion literature discusses how music can affect emotional states (Zentner, Grandjean & Scherer, 2008), and demonstrates how particular songs can manipulate certain emotions (Westermann et al., 1996). The current study supports existing literature that music is an effective means of inducing emotional states in the laboratory (Willner & Jones, 1996) and adds to the literature supporting the idea that individuals are adept at choosing songs or genres of music evoke particular emotions (Bull, 2005).

Results supporting the effectiveness of listening to a selection of preferred music as an effective manipulation of positive emotions notwithstanding, participants who listened to the music did not self-regulate better than controls who engaged in quiet rest. Because the data did not support the hypothesis, discussion of issues surrounding assumptions of the broaden and build theory, other experimental findings, and the methods employed in the present study is warranted.

Why positive emotion did not replenish self-regulation strength: Theoretical implications

Fredrickson's (1998) theory contends that the experience of positive emotion broadens one's scope of attention and cognition and advances one's ability to build the necessary physical and psychological resources required to excel in a given situation. The results of the current study did not support the predictions made by Fredrickson. Therefore, questions arise as to whether or not the effects of being in a positive emotional state may have some boundary conditions. One question is: How much positive emotion is necessary to overcome self-regulatory strength depletion? People vary in terms of how much positive emotion they experience from time to time. Thus, when individuals participate in a study, their baseline positive emotion can be low, moderate, or even high. Consequently, the potential effects of a manipulation designed to increase positive emotion may be restricted when people are not initially in a low positive emotional state. Recall participants in the present study had baseline PANAS positive emotion scores that were at the mid-point of the response scale ($M = 29.6$, $SD = 8.18$). The moderate baseline scores for positive emotion may therefore explain the results of the current study, as the scope for increasing positive emotion was limited and participants in the control conditions reported moderately positive emotional states as well. It is not clear from Frederickson's predictions whether or not the broaden and build phenomenon may only be observed when positive emotional states are contrasted with negative emotional states.

It is also not clear from Frederickson's predictions whether or not the broaden and build phenomenon may only be observed when positive emotional states increase dramatically. In the present study, although there was a small increase in positive emotion (effect size = 0.11), it may not have been a large enough effect to cause a change in self-regulation strength. With these issues in mind, future studies should investigate the effects of positive emotion manipulations on self-regulation for isometric handgrip persistence using groups that differ drastically (i.e., very high versus very low) in positive emotional states or among participants that experience large increases in positive emotion prior to a self-regulatory strength challenge.

Another consideration underlying the lack of supportive findings for Frederickson's (1998) broaden and build theory is the nature of the sustained isometric handgrip squeeze as an indicator of self-regulation strength that is amenable to the broaden and build phenomenon. The main tenet of the broaden and build hypothesis is that positive emotions augment the repertoire of thoughts and actions that a person may draw from when required to perform in a given situation (Fredrickson, 2001). Therefore, self-regulatory tasks requiring cognitive breadth such as problem-solving or decision-making tasks may show stronger effects of positive emotional states because they require an expanded repertoire of thoughts and actions to perform effectively. In contrast, tasks that require less breadth of cognitive or physical investment may not display the benefits resulting from positive emotion. In the context of the present study, the positive emotions induced in participants may not have improved handgrip performance simply because the task itself did not require broadening. In fact, focusing one's effort on squeezing a handle may require a narrowing of resources rather than broadening. Thus, the broaden and build theory may be limited, or more applicable, to tasks that require an increased repertoire of thoughts and actions in order to succeed.

Although the extent to which broaden and build mechanisms may be limited in application to simple tasks such as a handgrip squeeze, additional questions about handgrip squeezing exercise as a self-regulation challenge also arise. While sustaining a prolonged submaximal handgrip squeeze clearly requires someone to exert effort that may stretch their normal limits of self-regulation, isometric handgrip exercise further results in muscle fatigue, which consists of (at least) two additional components: peripheral fatigue and central fatigue (Taylor & Gandevia, 2008). Peripheral fatigue occurs at the level of the peripheral musculature when the force required to perform an exercise exceeds the capacity of the muscle fibers. Central fatigue occurs in the nervous system and affects the voluntary activation of the muscle motor units required to perform an exercise (cf. Taylor & Gandevia, 2008). Fatigue at the level of the muscle has been shown to occur more rapidly when greater forces are required by a task (Taylor & Gandevia, 2008).

Sustaining an isometric handgrip squeeze at a 50% MVC load is a voluntary task that induces rapid muscle fatigue and, therefore, task failure is imminent regardless of one's self-regulatory strength. In other words, someone may wish to sustain the contraction longer, but fail because their physiological (metabolic, neural, etc.) limits have been reached. Thus, in contrast to cognitive or emotion self-regulation tasks that one might carry out indefinitely (e.g., puzzle solving, thought suppression), performance of the isometric handgrip task is more likely to be constrained by physical limitations and less affected by positive emotional states that one might broaden and build from in order to increase stamina. A future study that involves an isometric handgrip task designed to induce a slower onset of muscular fatigue (such as a 20-30% MVC task) might allow greater latitude for mechanisms governing and moderating self-regulation of physical stamina to be more clearly observed.

Considered together, potential boundary conditions of Fredrickson's broaden and build theory and the physiological limitations imposed by peripheral and central contributions to muscle fatigue offer possible explanations that could account for the results in the present study. However, given a previous study by Tice et al (2007; Study 3) did find positive emotional states replenished self-regulatory strength for a handgrip squeezing task, a comparison of the procedures used in this study with previous literature also warrants some discussion.

Why positive emotion did not replenish self-regulation strength: Empirical Contrast

The empirical findings guiding the hypotheses in the present study were those of Tice et al. (2007). Recall to the four studies summarized in the literature review, in which the researchers investigated effects of positive emotional state manipulations on participants' subsequent self-regulatory strength. Tice et al.'s findings showed significant differences in self-regulatory strength between participants in the positive emotion induction conditions compared to controls in each of those investigations. Their self-regulation criterion measures involved a handgrip task and several other self-regulatory strength tasks including drinking a foul tasting beverage, persistence on a frustrating no-win game and time spent working on unsolvable figure tracing puzzles. As mentioned earlier, the broaden and build theory may apply with greater relevance to the latter tasks, however, it was Tice et al.'s Study 3 design that was most similar to the current study, as the outcome variable was handgrip endurance.

The experiment reported by Tice et al. (2007) in Study 3 involved three emotion conditions: positive, sad and neutral. They found that the positive emotion condition performed better than both sad and neutral condition, yet questions arise with respect to the reporting of emotional states following emotion manipulations as well as baseline handgrip performance in that study. Specifically, they reported positive and sad emotion increased following positive and sad emotion manipulations respectively, but did not report the emotional state for the neutral (control) group. As in the present study, a necessary condition for inferring the effect of positive emotion on self-regulation strength is a significant difference in emotion between the neutral (i.e., control) and positive emotion groups. Because those results were not reported, it is not clear if their emotion manipulation resulted in any difference between positive and neutral conditions. Therefore, it is not possible to conclude that positive emotion was the mechanism that affected handgrip endurance in that study. In addition, participants in Tice et al.'s Study 3 did not report their baseline emotional states. Thus, it is not clear whether or not participants in the positive emotion condition began the study in a positive mood and remained in that state after watching the humourous video clip. If participants in the positive emotion condition had been in more positive emotional states than participants in the other conditions, it casts doubt on the validity of the findings as they may have been able to perform better on both self-regulation tasks regardless of the emotion manipulation. Due to the lack of information reported for the neutral emotion condition and the missing baseline mood data in Tice et al.'s Study 3, several alternative explanations for their findings are conceivable and it is difficult to compare their results with the results of the current study.

Another distinct difference between the present study and Tice et al.'s Study 3 is that the positive emotion induction manipulation lasted 2 minutes in the current study, while it lasted 5 minutes in the Tice et al. study. Thus, because the Tice et al. emotion induction lasted more than twice the length of time, it is possible that a longer manipulation may have led to greater increases in positive emotion in their study. Again, because those data are not available, this possible difference cannot be evaluated.

A third point of contrast lies in the characteristics of the different handgrip tasks used in the Tice et al.'s (2007) study and the present study. The handgrip device used in Tice et al.'s study was spring-loaded and the task involved participants squeezing the handgrip to pinch a wad of paper between the handles. This task conforms to what is referred to as a "position" task (Hunter, Yoon, Farinella, Griffith & Ng, 2008). The current study employed a handgrip dynamometer which involved performing MVCs at the outset of the study to determine force for the endurance task which required participants to squeeze the handgrip to generate and sustain a force equivalent to 50% of their MVC. Hunter et al. (2008) refer to this type of isometric contraction task as a "force" task. Muscle fatigue patterns are starkly different for position vs. force tasks (Hunter et al. 2008), which may have affected handgrip endurance patterns as well. Also, because the amount of force required to perform the isometric handgrip task in Tice et al.'s study was also not reported, it is unknown whether the force requirements of the handgrip task in Tice's study were different from the 50% MVC task in the current study. Together, differences in the type of isometric contraction task as well as differential force requirements are likely sources of discrepant findings between the two studies.

Another set of results that was not reported by Tice et al. was the mean seconds to handgrip failure for each trial. The amount of time the persistence task required relates to the earlier point regarding the different muscle fatigue demands of isometric handgrip tasks that require different levels of force generation. Higher force requirements produce different fatigue patterns than lower forces, with faster fatigue occurring under higher force loads (Hunter, 2009). The mean of the handgrip endurance for all conditions in the current study were between 54 and 70 seconds. It is unclear whether participants in Tice et al.'s study held the handgrip for 2 minutes or 10 minutes before the wad of paper fell out indicating individuals' self-regulatory failure. Perhaps if the force requirements of Tice et al.'s handgrip task were lower, it invoked a more gradual onset of fatigue. Greater interpretational clarity would be gained had Tice et al. reported the performance scores (mean seconds to handgrip failure) as well as the force requirements of the spring loaded handgrip device.

One last contrast between the studies was that the current study employed 30 participants per condition, (24 after adjusted for RPE scores) while Tice et al.'s study included only 14 participants per condition. Due to sampling variability, a low number of participants raises questions about the reliability of the effects found in Tice et al.'s study. Small sample sizes increase the probability of both Type I and Type II errors occurring (Field, 2005), therefore, future studies involving a greater number of participants would help establish the reliability of the effects of positive emotional states on isometric handgrip muscular endurance.

In sum, when comparing the current study with Tice et al.'s study, there were several subtle, but potentially influential differences between the isometric handgrip tasks, the duration of positive emotion induction procedures, and the sample size, which could have led to the incongruent results. Furthermore, because Tice et al. did not report such details as the neutral emotion condition scores and the force requirements of the spring loaded handgrip device, it made replication of their study impossible. These factors coupled with variations in the methodology leave several unanswered questions about the generalizability of the effects of positive emotional state manipulations on self-regulation strength that will require future study to resolve.

Study Limitations

The present study yielded several expected and unexpected findings and is not without limitations. One limitation that deserves note is a potential threat to internal validity. In their meta-analysis of mood induction procedures, Westermann et al. (1996) have commented that demand characteristics plague much of the research on emotional states. Specifically, they note there is potential for mood induction procedures to encourage biased overestimation of reported emotions as participants intuitively sense they are expected to react in a certain manner to the manipulation they are given. In the present study, participants may have felt the need to rate their positive emotions as more positive on the PANAS after listening to the music emotion induction because the song played for them was one they found to be uplifting. If there was no real change in positive emotion, it would explain the lack of difference in the handgrip endurance between conditions. While demand characteristics can not be ruled out, music listening has been demonstrated to be an effective emotion induction procedure (Westermann et al., 1996) and has been shown to produce reliable changes in emotion (Juslin, Lilestrom, Vastfjall, Barradas, & Silva, 2008). Given the small effect of listening to music on positive emotion in the study, the possible contribution of demand characteristics to the emotion manipulation poses limits on the extent to which listening to uplifting music can be used to manipulate positive emotional states.

The sample size was also a limitation in the current study. Using Cohen's (1992) guidelines for estimating sample size requirements, it was calculated that in order to detect a small to medium effect size, 30-40 participants were required per condition. Unfortunately, 18 of the participants reported questionably low RPE values after the first handgrip task, which led them to be eliminated from the analyses. With only 24 participants left in each condition, the chances of finding a small or medium effect size were significantly diminished. A future study employing 50 or 60 participants per condition would increase the chances of detecting small effects.

Study Strengths

Balanced against the aforementioned limitations to the study are a number of strengths. A major strength of the study was its grounding in theory. The study drew from an established literature on self-regulation failures that show convincingly that people have a limited resource that governs their abilities to self-regulate thoughts, emotions, and actions. The predictions of the study were also grounded in Frederickson's (1998) broaden and build theory of emotion and evidence from the behavioural neuroscience literature linking dopaminergic activation in the PFC and ACC to self-regulation. Thus, the study offered an integrated theoretical perspective on a modifiable factor (positive emotion) that could affect people's abilities to self-regulate exercise behaviour.

Another strength of the study was its design, which involved pre- and post-manipulation assessments of positive emotional states that were examined as interim mechanisms that could affect self-regulation strength depletion. As argued earlier, previous research by Tice et al. (2007) did not establish changes in positive emotional states as a reliable mechanism that affects self-regulation depletion patterns involving handgrip exercise. Thus, although the present study did not show that increases in positive emotion were associated with better self-regulation, it may be considered a more valid test of the hypothesis that increasing positive emotion should result in better self-regulation of exercise endurance.

The study is also noteworthy in terms of its novel investigation of music listening as method of emotion induction. Listening to music is a practice that people commonly use in a variety of self-regulatory contexts, including exercise. Personal music playing devices are commonly seen being used by individuals at the gym exercising, or out walking or running on streets and trails. This phenomenon has not been observed in a laboratory setting in terms of how it may help in overcoming self-regulatory depletion. Conditions under which one feels depleted after self-regulatory strength utilization, may be just the time to plug into a playlist of one's favourite uplifting music prior to hitting the gym for a workout. However, future research is needed to investigate such effects. As noted earlier, the relative simplicity and brevity of the isometric handgrip task used in this study may not allow for a good reflection of the effects listening to music may have on more complex and lengthy exercise tasks such as running for 30 minutes or completing a circuit of strenuous exercise. Perhaps exercises performed in a naturalistic environment may allow one to broaden and build from a positive emotional state. Unfortunately, the isometric handgrip task was not able to tap into this potential in the lab. The effects of music as a factor affecting self-regulation of more complex physical tasks should be investigated in future research.

Future Directions

It is important to acknowledge and appreciate the strengths and limitations of the current study in order inform future potential studies and directions for further research. Several avenues of future research have already been suggested throughout the discussion chapter. However, in order to gain a better understanding as to how emotion manipulations differ in the actual positive emotions they evoke and the role they play on replenishing self-regulatory depletion, an examination of alternative methods of positive emotion manipulation should be explored. For example, a study investigating the effects of a comedy clip, a music manipulation, as well as a control condition may be a good consideration for future work. There is a chance that different forms of positive emotion are evoked when comedy clips are viewed compared to those experienced when favourite music selections are heard. That is, people seldom burst out laughing when they hear their favorite song, but often do so when they hear a good joke. Because of the complex range of positive emotions that may be experienced, different emotion manipulations and measures of positive emotion should be investigated. Additionally, fMRI scans of individuals watching funny movies versus listening to their preferred music might provide interesting results that may relate back to the neurological effects of positive emotion and potentially will allow for greater understanding of where and how dopamine activation and cerebral structures such as the PFC and ACC are involved in self-regulation.

As discussed earlier on, because of the physical limitations associated with the handgrip task, using a task that is not as physiologically taxing as the one in the current study (participants holding the device at 50% MVC) may better address the broaden and build theory in a future study. One possibility would be to have participants engage in an exercise related task that is not as physically taxing on one small muscle group. For instance, participants could ride on a stationary bicycle for an hour at an RPE level that they predetermine at the beginning of the study as a task requiring self-regulation. Martin Ginis & Bray (in press) found that the Stroop depletion task had an effect on subsequent aerobic exercise, where participants performed an exercise bout at a lower level of work output (a negative change in kJ) following self-regulation strength depletion. It would be interesting to determine if participants in a similar study would self-regulate better if they listened to a selection of preferred music before or during the cycling task. In order for exercise psychologists to make empirically-founded recommendations for how individuals can adopt and maintain regular exercise routines, it is important for us to understand how people can manipulate their exercise environment by listening to music and other means to optimize their abilities to self-regulate exercise behaviour.

Summary & Conclusions

The present study set out to investigate the effects of listening to self-selected uplifting music on positive emotional states and sought to understand the effects of varying positive emotional states on self-regulatory strength depletion patterns. It was found that participants who listened to a preferred music selection showed a significant increase in positive emotional states and scored higher on the positive emotion scale of the PANAS after listening to music, compared with controls who rested quietly. Additionally, those who engaged in the self-regulatory depletion (Stroop) task showed significant negative change in handgrip endurance compared to the No Depletion control group. However, the participants who were induced into a positive emotional state following depletion did not show replenishment effects on the second handgrip task.

In light of the present findings, it is difficult to conclude that positive emotional states have a beneficial impact on self-regulation strength. However, given previous findings by Tice et al. (2007) and the concerns and limitations associated with the design of the present study, it is possible that future research can better determine whether positive emotional states can help people renew their self-regulation strength, or whether such effects occur only with specific tasks and under specific conditions. Therefore, although results did not support the idea that positive emotions replenish self-regulatory depletion in times of need, further research is warranted to investigate the implications that music and positive emotion may have for the self-regulation of exercise.

References

Albersnagel, F. A. (1988). Velten and musical mood induction procedures: A comparison with accessibility of thought associations. *Behavioural Research Therapy, 26*, 79-96.

Arias-Carrion, O. & Poppel, E. (2007). Dopamine, learning, and reward-seeking behavior. *Acta Neurobiologiae Experimentalis, 67*, 481-488.

Banfield, J. F., Wyland, C. L., Macrae, C. N., Munte, T. F., & Heatherton, T. F. (2004). The cognitive neuroscience of self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory and applications* (pp.62-83). New York: Guilford.

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

Baumeister, R. F. (2003). Ego Depletion and Self-Regulation Failure: A Resource Model of Self-Control. *Alcoholism: Clinical and Experimental Research, 27*, 281–284.

Baumeister, R. F. (2006) Self-Regulation and Personality: How Interventions Increase Regulatory Success, and How Depletion Moderates the Effects of Traits on Behavior. *Journal of Personality, 74*, 1773-1802.

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

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

Baumeister, R. F. & Vohs, K. D. (Eds.) (2004), *Handbook of self-regulation: Research, theory and applications* (pp. 1-9). New York: Guilford.

Baumeister, R. F. & Vohs, K. D. (2007). Self-regulation, ego depletion and motivation. *Social and Personality Psychology Compass 1*, 10.1111/j.

Baumeister, R. F., Vohs, K. D., DeWall, C. N., & Zhang, L. (2007). How emotion shapes behavior: Feedback, anticipation, and reflection, rather than direct causation. *Personality and Social Psychology Review, 11,* 167-203.

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences (PNAS) Biological Sciences, 98,* 11818–11823.

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

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, 44*, 337-343.

Bray, S. R., & Martin Ginis, K. A. (2009). Self-regulatory Strength Depletion and Muscular Endurance: A Test of the Limited Strength Model in Older Adults. Manuscript submitted for publication.

Browning , C. (2000). Using music during childbirth. *Birth, 27,* 272-276.

Bull, M. (2005). No dead air! The iPod and the culture of mobile listening. *Leisure Studies, 24,* 343-355.

Burgdorf, J. & Panksepp, J. (2006). The neurobiology of positive emotions. *Neuroscience & Biobehavioral Reviews, 30,* 173-187.

Christenson, P., & Roberts, D. F. (1998). It's not only rock and roll: Popular music in the lives of adolescents. Cresskill, NJ: Hampton Press.

Clayton, C. S. (2008). *Self-regulatory depletion, muscular endurance and EMG activity: An examination of depletion effects and trait self control as an effect modifier.* Unpublished master's thesis, McMaster University, Hamilton, Ontario, Canada.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112,* 155-159.

Declerck, C. H., Boone, C., & DeBrabander, B. (2006). On feeling in control: A biological theory for individual differences in control perception. *Brain and Cognition, 62*, 143-176.

Dishman, R. K. (1988). Exercise adherence: Its impact on public health. Champaign, IL; Human Kinetics Books.

Field, A. (2005). Discovering Statistics Using SPSS. 2nd Ed. London, GB: Sage Publications.

Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology, 2,* 300-319.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56,* 218–226.

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

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

Godin, G. & Shephard, R. J. (1985). A simple method to assess exercise behaviour in the community. *Canadian Journal of Applied Sport Sciences, 10,* 141-146.

Hayakawa, Y., Miki, H., Takada, K & Tanaka, K. (2000). Effects of music on mood during bench stepping exercise. *Perceptual Motor Skills, 90,* 307-314.

Health Canada. (2002). Physical Activity Readiness Questionnaire. Retrieved on Sunday, September, 6, 2009 http://www.phac-aspc.gc.ca/sth-evs/english/parq-eng.php

Hunter, S. K. (2009). Sex differences and mechanisms of task-specific muscle fatigue. *Exercise and Sport Science Reviews, 37,* 113-122.

Hunter, S. K., Yoon, T., Farinella, J., Griffith, E. E. & Ng, A. V. (2008). Time to task failure and muscle activation vary with load type for a submaximal fatiguing contraction with the lower leg. *Journal of Applied Physiology, 105,* 463-472.

Juslin, P. N., & Sloboda, J. A. (Eds.). (2001). *Music and emotion: Theory and research.* Oxford: Oxford University Press.

Juslin, P. N., Lilestrom, S., Vastfjall, D., Barradas, G., & Silva, A. (2008). An experience sampling study of emotional reactions to music: Listener, music and situation. *Emotion, 8,* 668-683.

Liu, J. Z., Shan, Z. Y., Zhang, L.D., Sahgal, V., Brown, R. W., & Yue, G. H. (2003). Human brain activation during sustained and intermittent submaximal fatigue muscle contractions: An fMRI study. *Journal of Neurophysiology, 90,* 300-312.

Mai, X. Q., Luo, J., Wu, J. H., & Luo, Y. J. (2004). ''Aha!'' effects in a guessing riddle task: An event-related potential study. *Human Brain Mapping, 22*, 261–270.

Martin, M. (1990). On the induction of mood. *Clinical Psychology Review, 10*, 669-697.

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

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

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

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

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

Phillips, L. H., Bull, R., Adams, E., & Fraser, L. (2002). Positive mood and executive function: Evidence from Stroop and Fluency tasks. *Emotion, 2*, 12–22.

Saarikallio, S., & Erkkilä, J. (2007). The role of music in adolescents' mood regulation. *Psychology of Music, 35*, 88-109.

Sloboda, J.A. & O'Neill, S. A. (2001) 'Emotions in Everyday Listening to Music', in P.N Juslin and J.A. Sloboda (eds) *Music and Emotion: Theory and Research*, pp. 71–104. New York: Oxford University Press.

Taylor, J. L. & Gandevia, S. C. (2008). A comparison of central aspects of fatigue in submaximal and maximal voluntary contractions. *Journal of Applied Physiology, 104,* 542-550.

Thayer, R. E., Newman, J. R. & McClain, T. M. (1994) Self-regulation of mood: Strategies for changing a bad mood, raising energy, and reducing tension. *Journal of Personality and Social Psychology, 67,* 910–25.

Tice, D. M., & Baumeister, R. F. (1997). Longitudinal study of procrastination, performance, stress, and health: The costs and benefits of dawdling. *Psychological Science, 8,* 454-458.

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

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

Wells, A. and Hakanen, E. A. (1991) 'The Emotional Use of Popular Music by Adolescents. *Journalism Quarterly, 68,* 445–454.

Westermann, R., Spies, K., Stahl, G., & Hesse, F. W. (1996). Relative effectiveness and validity of mood induction procedures: A meta-analysis. *European Journal of Social Psychology, 26,* 557–580.

Willner, P. & Jones, C. (1996). Effects of mood manipulation on subjective and behavioural measures of cigarette craving. *Behavioural Pharmacology, 7,* 355-363.

Wyland, C. L., Kelley, W. M., Macrae, C. N. Gordon, H. L., & Heatherton, T. F. (2003). Neural correlates of thought suppression. *Neuropsychologia, 41*, 1863-1867.

Zentner, M., Grandjean, D., & Scherer, K. R. (2008) Emotions evoked by the sound of music: Characterization, classification, and measurement. *Emotion, 8*, 494-521.

Appendix A:

Consent Form

CONSENT TO PARTICIPATE IN RESEARCH: LAB-BASED STUDY
Endurance and Word Study
March 2009

You are being invited to participate in a research study carried out by Jennifer Bittner, Dr. Kathleen Martin Ginis, and Dr. Steven Bray (Dept. of Kinesiology, McMaster University). The study is sponsored by the Social Sciences and Humanities Research Council. If you have any questions or concerns about the study, please feel free to contact Jennifer Bittner at (905) 525-9140 ext. 24694 or Dr. Kathleen Martin Ginis (905) 525-9140 ext. 23574.

RATIONALE

This study is designed to provide information regarding people's physical fatigue and mood.

PURPOSE OF THE STUDY

The primary purpose of this study is to examine exercisers' endurance and word task abilities.

PROCEDURE

This study will take about 55 minutes to complete. It involves filling out some questionnaires, having electrodes attached to your forearm (which cause no pain or discomfort), performing a handgrip exercise, completing a brief reading task and filling out some more questionnaires.

POTENTIAL RISKS AND DISCOMFORTS

There are no known risks associated with taking part in this study. You might find the moderate exercise to cause fatigue and minor muscle soreness. If you experience any pain besides fatigue while doing the exercises you should tell the researcher immediately and stop the exercise. You might also experience some frustration or anxiety in connection to the word tasks.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

There are no direct benefits to you from taking part in this study.
The results from this study will help the scientific community better understand the effects of cognitive tasks on endurance and exercise choices.

PAYMENT FOR PARTICIPATION

You will be compensated $15 for your participation in the current study.

CONFIDENTIALITY

We will be using a code ID to identify you as a participant, so your identity will not be revealed at any time. 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 or as required by law. 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. 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. You may withdraw at any time without penalty and you will still receive compensation for participating. If you withdraw, any data you have provided to that point will be destroyed unless you indicate otherwise. You may also refuse to answer any questions you don't want to answer while remaining in the study.

RIGHTS OF RESEARCH PARTICIPANTS

You are not waiving any legal claims, rights or remedies because you are participating in this research study. This study has been reviewed and received ethics clearance through the McMaster Research Ethics Board (MREB). If you have any questions regarding your rights as a research participant, contact **The McMaster Research Ethics Board Secretariat c/o the Office of Research Ethics, McMaster University [Phone: (905) 525-9140 ext. 23142]. Email: ethicsoffice@mcmaster.ca**

INFORMATION REGARDING STUDY RESULTS

This study is expected to be completed by May, 2009. If you are interested, please contact **Jennifer Bittner** at **bittnejp@mcmaster.ca** for a summary of the results.

SIGNATURE OF RESEARCH PARTICIPANT

I understand the information provided for the study ***Endurance and Word Study*** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I will receive a signed copy of this form.

____

Name of Participant

________________________________ ____________

Signature of Participant Date

Consent form administered and explained in person by:

____

Name and title

________________________________ ____________

Signature Date

SIGNATURE OF INVESTIGATOR

In my judgement, the participant is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

________________________________ ____________

Signature of Investigator Date

Appendix B:

Questionnaire Package

Musical Preference Elicitation Questionnaire

Age: _____

Please answer the following questions:

Do you consider yourself to be a music lover?

Please circle

YES **NO**

1. **Who is your favourite musical performer (artist/band)?**

   ____

2. **What is your favourite piece of music (song or instrumental)?**

   ____

3. **What are your top 3 favourite uplifting musical selections right now and who performs them?**

   1.______________________________
   2. ______________________________
   3. ______________________________

4. **What is your LEAST favourite musical selection right now and who performs it?**

   ____

EXERCISE SCREENING QUESTIONNAIRE

Date: ______________________________

Age: __________

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?

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)

EXERCISE SCREENING QUESTIONNAIRE (PAR-Q)	YES	NO
1. Has your doctor ever said that you have a **heart condition** <u>and</u> that you should only do physical activity recommended by a doctor?	☐	☐
2. Do you feel **pain in your chest** when you do physical activity?	☐	☐
3. In the past month, have you had **chest pain** when you were not doing physical activity?	☐	☐
4. Do you lose balance because of **dizziness or do you lose consciousness**?	☐	☐
5. Do you have a **bone or joint problem** (for example, back, knee or hip) that could be made worse by a change in your physical activity?	☐	☐
6. Is your doctor currently prescribing **drugs** (for example, water pills) for your **blood pressure** or heart condition?	☐	☐
7. Do you know of <u>any other reason</u> why you should not do physical activity?	☐	☐

DEMOGRAPHICS

We are interested in getting to know some basic information about you. Please complete the following questions.

Age: _____

Gender: Female _____ Male _____

Marital Status: Single ____ Married ____ Divorced ____ Common-law ____ Widowed ____

Ethnicity: Caucasian ____ Asian ____ African American ____ Other ____

At McMaster, are you a: Undergraduate Student _____
Graduate Student: _____
Faculty: _____
Staff: _____
Other: _____

MANIPULATION CHECK

These items are statements about your reactions to the word 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 word task?

1 2 3 4 5 6 7

Little Effort **Extreme Effort**

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

1 2 3 4 5 6 7

Not Tired **Extremely Tired**

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

1 2 3 4 5 6 7

Not Frustrated **Extremely Frustrated**

4. How pleasant did you find doing the word task?

1 2 3 4 5 6 7

Extremely Unpleasant **Extremely Pleasant**

POSITIVE AND NEGATIVE AFFECT SCHEDULE (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicated to what extent **you feel this way right now, that is, at the present moment**. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	**slightly**	**moderately**	**quite a bit**	**extremely**

_______ interested	_______ irritable
_______ distressed	_______ alert
_______ excited	_______ ashamed
_______ upset	_______ inspired
_______ strong	_______ nervous
_______ guilty	_______ determined
_______ scared	_______ attentive
_______ hostile	_______ jittery
_______ enthusiastic	_______ active
_______ proud	_______ afraid

Appendix C:

Rating of Perceived Exertion (RPE) Scale

Rating your Physical Performance – Endurance Task

Below is a scale, from 1 to 10, that provides a rating of how much effort you felt you exerted while performing the endurance task.

RPE Numeric Value	Definition
1	**Very Weak Effort** When I performed the task, I put forward little to no effort at all.
2	
3	**Little Effort** I put forward some effort, but did not exert myself.
4	
5	**Moderate Effort** I tried pretty hard to go for a long time, but I think I could have gone longer.
6	**Strong**
7	**Very Strong Effort** I did push myself to go for as long as I could.
8	
9	
10	**"All-out" Effort** There was no way I could have performed the task for any longer. I put everything I had to go to the very end.

Appendix D:

Debriefing Form

Debriefing Form
For the Study entitled:
"Endurance and Word Study"
March 2009

Dear Participant;

Prior to this study, you were told that you would be completing some questionnaires, performing a word task and performing an isometric endurance task. You were told that the purpose of the study was to examine exercisers' endurance and word task abilities. The actual purpose of the study was to see how long you could endure on the isometric task (handgrip) after performing the Stroop colour/word task or the reading task. Some people listened to their favourite music before they did the second exercise task, while other listened to no music. We were interested in whether listening to your favourite music would change your handgrip performance, theoretically by replenishing your depleted self-regulation. The electrodes were attached simply to get a better understanding of the activity occurring at the level of the muscle.

You are reminded that your original consent document included the following information: "You can decide whether to take part in this study or not. You may withdraw at any time without penalty and you will still receive compensation for participating. Any data you have provided to that point will be destroyed unless you indicate otherwise." If you have any concerns about your participation or the data you provided in light of this disclosure, please discuss this with us. We will be happy to provide any information we can to help answer questions you have about this study.

If your concerns are such that you would now like to have your data withdrawn, we will do so.

If you have questions about your participation in the study, please contact me at bittnejp@mcmaster.ca, or my faculty advisor, Kathleen Martin Ginis; martink@mcmaster.ca.

If you have questions about your rights as a research participant, you may contact the McMaster Research Ethics Board Secretariat c/o the Office of Research Ethics, McMaster University [Phone: (905) 525-9140 ext. 23142]. Email: ethicsoffice@mcmaster.ca

Please again accept our appreciation for your participation in this study.

Jennifer Bittner March 2009

Appendix E:

Protocol Scripts – All Conditions

Jen's Thesis Protocol and Script – All Conditions

1. Participant Recruitment:

Potential volunteers will be recruited through:

- The McMaster Daily News sites
- Email contacts from previous studies which use this demographic
- Person to person contact through participants (referrals)

2. Participant Screening Procedure:

Participants will be screened for:

- **Colour blindness**
- **No physical limitations**

3. Schedule participants

- The day before their scheduled appointment **remind participants** of where to come to and the time of their scheduled appointment, including what to wear. As well, send them a contact phone number that they can use to call if there is a problem.
- Explain to them that they need to come to the South Entrance of the IWC and to ask the parking attendant how to get there.

MATERIALS NEEDED IN THE LAB:

1. Informed consent, musical preference sheet, exercise screening questionnaires & demographics

- When participants arrive at the lab they will be given the informed consent questionnaires and demographic measures to fill out immediately.

  "Now I am just going to review with you what you will be doing during this session today. The whole study should take about 55 minutes to complete. First you will fill out this consent form, screening questions and demographic information. Second, I will be sticking some electrodes on your forearm muscles. You will then be asked to squeeze this handgrip unit here for various lengths of time. You will then be completing a brief reading task and filling out some more questionnaires. Then you will be finished! How does that sound?"

2. Attach EMG electrodes:

- Shave area if necessary, clean area, attach
- Have participant squeeze for a second to make sure it is all set up right.

3. Single Maximum Voluntary Contractions (2):

- Ask participant to squeeze and hold for 5 seconds

"Okay, so first what I would like you to do is, when I say 'start,' squeeze the handgrip as hard as you possibly can – everything you've got. You will hold that for 5 seconds, and I will tell you to stop. Okay? Start....Stop"

- Participants will then be asked to rate how hard they worked (1 to 10) by showing them the Rating of Perceived Exertion Scale (RPE). They will rest for **30 seconds** before repeating the MVC for the second time.

"Okay, so you will just rest for 30 seconds before we do that one more time. Do you feel okay?"
30 Seconds go by: **"Alright, so again, when I say 'start,' you squeeze the handgrip as hard as you possibly can – everything you've got. You will hold that for 5 seconds, and I will tell you to stop. Okay? Start....Stop"**

"Great, thank you. Now you are going to just rest for 2 minutes."
(during this time I will download their favourite song from itunes)

4. Fatigue Trial Pre Manipulation:

- I will now set up the screen so that the line is at their 50% MVC and they will be able to see where they have to keep their spot.
- After 2 minutes of rest, I will have them do a 10 second practice keeping their squeeze above the line on the screen.

"Okay, so now that you have rested, I am going to show you this screen here. Now this line on the screen is where I need you to keep the line that shows up when you squeeze above. So a red line will appear when you squeeze the handgrip, and I need you to make sure it doesn't drop below this line. Does that make sense? Okay, we will practice for 10 seconds."

- After the 10 seconds, they will rest for another **2 minutes** and I will say:

"Okay, now what you are going to do is hold that squeeze above that line for as long as you possibly can. Until you feel completely too tired in your arm to go on. I will ask you to keep it above the line if at any time it falls below, and you just tell me when you are getting to the end point where you can no

longer hold it. Any questions? It cannot fall below the line for longer than 1 second – which is represented by these squares"

5. Randomize participants to Control or Self-Reg Depletion groups and music or non music exposure:

- Colour-word mismatch = Self-reg depletion
- Colour word match = Control
- Music exposure = Positive Emotion Induction
- Quiet Rest = control

6. Stroop Test – 5 minutes

<u>FOR THE STROOP/MUSIC CONDITION:</u>

- Provide participant with a list of 135 words (3 sheets) that are all the names of colours (e.g., RED, BLUE). However, the words and their ink colours will be mismatched (e.g., RED printed in green ink and BLUE printed in yellow ink).
  "Now I am going to have you do a reading task. For this reading task I am going to ask you to read out loud the ink colour of each word, unless the ink colour is red, in which case you must ignore the ink colour and just read the word to me. I will be timing you while you read the words, so try and read them as quickly and as accurately as you can, and I will tell you when you need to stop. If you make a mistake just keep going through the words."
  "Just so that I know you understand the instructions I am going to have you practice with these five words (provide participant with practice sheet).
  "Great. Again read the ink colour of each word out loud, unless the ink colour is red, in which case you must ignore the ink colour and just read the word to me. If you finish the three sheets of words just start back again at the first sheet. Once again, keep going until I tell you to stop."
  "Do you have any questions? Ok you can start."
  - Record the number of errors on the record sheet.
  - Keep track of the time on the stop watch and stop participant at 5 minutes

<u>FOR THE CONTROL CONDITION:</u>

- Provide participant with a list of 135 words (3 sheets) that are all the names of colours (e.g., RED, BLUE). The words and their ink colours will be matched (e.g., RED printed in RED ink and BLUE printed in BLUE ink).

  "Now I am going to have you do a reading task. For this reading task I am going to ask you to read out loud the ink colour of each word, I will be timing you while you read the words, so try and read them as quickly and as

accurately as you can, and I will tell you when you need to stop. If you make a mistake just keep going through the words."

"Just so that I know you understand the instructions I am going to have you practice with these five words (provide participant with practice sheet).

"Great. Again read the ink colour of each word out loud. If you finish the three sheets of words just start back again at the first sheet. Once again, keep going until I tell you to stop."

"Do you have any questions? Ok you can start."

- Keep track of the time on the stop watch and stop participant at 5 minutes.

7. Manipulation check items:

- Participants will now complete post-stroop manipulation check questionnaire.

8. Emotion Measure – PANAS administered.

"Please fill out this questionnaire regarding how you feel right now, at this exact moment"

9. Music – emotion induction manipulation:

- Participant will sit still while I play 2 minutes of their favourite uplifting song.

"Now I am going to have you just sit and rest again for a few minutes, so please just try and relax."

No music condition – just sit quietly for 2 minutes:

- Participant will sit still while it is silent and they just rest.

"Now I am going to have you just sit and rest again for a few minutes, so please just try and relax."

10. Emotion measure time 2: PANAS administered again

"Please fill out this questionnaire regarding how you feel right now, at this exact moment"

11. Fatigue Trial Post Manipulation:

- I will now set up the screen so that the line is at their 50% MVC and they will be able to see where they have to keep their spot.
- After 2 minutes of music listening and filling out questionnaires they will be doing the fatigue trial again.

"Okay, now what you are going to do is hold that squeeze above that line for as long as you possibly can. Until you feel completely too tired in your arm to go on. I will ask you to keep it above the line if at any time it falls below, and you just tell me when you are getting to the end point where you can no longer hold it. Any questions? It cannot fall below the line for longer than ½ a second – which is represented by these squares. Does that make sense? It is exactly the same as what you did before."

12. De-Briefing and Remuneration:

- Debrief the participant, answer any questions thye have.
- Info letter is given to them to take home and they will be signing for remuneration.

"Okay, that concludes the experiment! You are all done. Good work."

DEBRIEFING STATEMENT:

"During this study, you were asked to squeeze the handgrip for various lengths of time at varying intensities. We know from previous studies that physical strength and stamina may be altered when people are exposed to different situations. You engaged in the reading task in between trials, which was the self-regulation depletion manipulation in this study. There were two reading conditions, one where the words and colours were congruent and the other where they were incongruent. There were also two conditions where participants were either exposed to their favourite uplifting song, or they were not. The purpose of the study was to see if you were more fatigued on the handgrip task after doing the reading task, depending on the condition you were exposed to and whether the music manipulated your emotions, so as to replenish this fatigue. If you are interested in the results of this study, you can put your name and email address on this list and we can follow up with you when the results are in"

"Thank you for your participation here is the $15. Now I need you to fill out this remuneration form to acknowledge that you received the money and if you would like a copy of the study results you can take this information sheet home and contact me by phone."