COGNITIVE EFFECTS OF OSTRACISM FOLLOWING AN ACUTE BOUT OF PHYSICAL ACTIVITY

By

Anthony G. Delli Paoli

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ABSTRACT

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Behavioral, psychological, and emotional effects of ostracism are well documented, however little is known about the effects of ostracism on aspects of higher order cognition. Executive functioning is an aspect of higher order cognition that may be temporarily disrupted by ostracism. Therefore, interventions designed to enhance executive functioning, such as an acute bout of physical activity, may counteract cognitive disruption. Accordingly, the purpose of this study was to test the effects of ostracism on executive functioning following an acute bout of physical activity. Using a within-subjects design, participants (N = 48, 24 female) completed three counterbalanced testing sessions where they received exercise and inclusion, exercise and exclusion, and rest and exclusion. Participants completed a total of three flanker tasks in each session as a measure of executive functioning. Results showed that exercise was beneficial for overall accuracy, $t(47) = -3.58$, $p < .05$, $d = 0.32$, and performance monitoring, $t(47) = -2.53$, $p < .05$, $d = 0.34$. Participants performed the same as baseline following exclusion or inclusion. Thus, despite finding an effect for exercise on executive functioning as well as psychological and emotional effects of ostracism, an effect of ostracism on executive functioning was not observed. It remains unclear if and precisely how ostracism affects executive functioning in college-aged young adults, and the role of exercise in any such relationship. However, the findings of this thesis point to important next research steps for exploring the connection of exercise, ostracism and executive functioning in college-aged young adults.

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KEY TO SYMBOLS AND ABBREVIATIONS

BPM	= beats per minute
EI	= exercise and inclusion condition
EX	= exercise and exclusion condition
HR	= heart rate, measured in beats per minute
LTEQ	= Leisure-Time Exercise Questionnaire
MET	= metabolic equivalent of task (e.g., a MET of 1 is equal to seated rest)
M	= retrospective questionnaires
MC	= mostly congruent stimuli
MI	= mostly incongruent stimuli
ms	= milliseconds (e.g., 1000 ms = 1 second)
P	= practice cognitive task
PA	= physical activity
PAR-Q	= Physical Activity Readiness Questionnaire
RX	= rest and exclusion condition
SMS	= Social Monitoring System
SPAI	= Social Anxiety and Phobia Inventory

CHAPTER ONE

INTRODUCTION

The behavioral, psychological, and emotional effects of ostracism are well documented, however little is known about the effects of ostracism on aspects of higher order cognition (Williams, 2007a; 2007b). Executive functioning is an aspect of higher order cognition that may be responsible for regulating the effects of ostracism (Hofmann, Schmeichel, & Baddeley, 2012). Recent empirical evidence shows that executive functioning may be disrupted following an event of ostracism which may lead to a host of maladaptive outcomes (Ball, 2011; Baumeister, DeWall, Ciarocco, & Twenge, 2005; Chester et al., 2013). Attempts to enhance executive functioning prior to an event of ostracism may counteract cognitive disruption. A growing body of literature suggests acute bouts of physical activity can improve executive functioning performance (Chang, Labban, Gapin, & Etnier, 2012; Hillman, Erickson, & Kramer, 2008; Kramer & Erickson, 2007). Therefore, exploratory efforts are warranted to test the utility of physical activity for counteracting the cognitive effects of ostracism.

Ostracism is the process of ignoring or socially excluding others (Gruter & Masters, 1986; Williams, 2007a). An event of ostracism can be deliberate, such as solitary confinement in prison, or subtle, such as ignoring the person beside you on a bus. All forms of ostracism involve a target (i.e., the victim) and a source (i.e., the perpetrator). Williams' (2009) temporal need threat model is a theoretical framework which proposes the target experiences the effects of ostracism in a progressive sequence. The first stage is reflexive (i.e., automatic) and includes a host of psychological and emotional effects. The reflexive stage includes the experience of social pain, a diminished sense of belonging, self-esteem, control, and meaningful existence needs, reduced positive affect, and increased negative affect (Williams, 2007a). An event of ostracism is painful, alerting the victim that one's social connections have been injured (Smart Richman & Leary, 2009; Williams & Zadro, 2005). This pain response is evidenced by self-report measures of distress following ostracism, physiological measures of increased blood pressure, and increased neurological activation of a brain region associated with physical pain (Eisenberger, Lieberman, & Williams, 2003; Williams, 2007a). Targets also report a reduced sense of belonging, self-esteem, sense of control and meaningful existence (Williams & Zadro, 2005). Another reflexive effect of ostracism is reduced positive affect and increased negative affect. Targets of ostracism consistently report a cluster of emotions representing "hurt feelings" (Smart Richman & Leary, 2009).

The reflexive stage is then followed by a reflective stage characterized by cognitive appraisals of the social situation in order to assess what happened and how to respond accordingly. During the reflective stage the target of ostracism engages in coping and self-regulatory strategies to reduce pain, restore a sense of the affected needs, and manage emotion (Williams, 2007a). This self-regulatory process is dependent on an aspect of higher order cognition called executive functioning (Hofmann et al., 2012). Executive functioning is an umbrella term that represents an array of interrelated mental processes responsible for purposeful, goal-directed behavior (Gioia, Isquith, & Guy, 2001). These mental processes include selecting, initiating, implementing, and planning behavior. One core component of executive functioning is inhibitory control (Diamond, 2012). Inhibitory control is the ability to actively control one's attention, behavior, thoughts, and/or an emotion to override a strong mental or behavioral habitual tendency, and instead do what is more appropriate or needed at the given moment (Diamond, 2012). Inhibitory control has been linked to self-control of behavior such as adequate social responding, resisting impulses that are emotionally charged, and monitoring planned behavior (Diamond, 2012; Hofmann et al., 2012). Inhibitory control is especially important for targets of ostracism because targets must inhibit the reflexive effects and any impulsive behavior that may interfere with the goal of regaining inclusion.

Targets generally respond to ostracism with a variety of behaviors intended to increase social acceptance or to regain a sense of control and recognition (Williams, 2007b). Behaviors intended to increase social acceptance are friendly, nice, and agreeable in order to restore or create new friendships and relationships. This pattern of responding is best achieved through monitoring social information and using that information in order to respond more favorably to others. Previous research shows that ostracism leads to increasing cooperation and remembering greater amounts of social information (Gardner, Pickett, & Brewer, 2000; Williams & Sommer, 1997). However, this pattern of responding is more cognitively challenging because it requires the ability to inhibit responses that would interfere with this process, regulate attention towards social information, and use the information gathered from social cues to attempt a behavior that would aide in increasing social acceptance (Ochsner & Gross, 2005; Williams, 2007a).

Behaviors intended to regain a sense of control and recognition appear to be maladaptive (Williams, 2007b). Targets who seek to regain a sense of control and recognition fail to thoughtfully appraise the situation and appear to ignore social information that may aide in regaining social acceptance. This suggests a temporary disruption in executive functioning performance because targets fail to inhibit the reflexive effects of ostracism and this may lead to self-defeating behavior. A line of research investigating social exclusion found targets respond in a way that reflects failures in self-regulation, self-defeating unhelpful behaviors, and aggression (Baumeister, Brewer, Tice, & Twenge, 2007; Twenge, 2005; Twenge, Baumeister, Tice, & Stucke, 2001; Williams, 2007b). Baumeister and colleagues (2005) label this cognitive deconstruction. They argue that the experience of social exclusion may be so cognitively challenging that impairments in cognition (i.e., executive functioning) arise. Therefore, executive functioning appears to be critical during the reflective stage to regulate the reflexive effects of ostracism so the target can thoughtfully appraise and monitor the current social situation.

The process of monitoring is an important cognitive process that is essential for regaining inclusion. Social monitoring is an adaptive process involving the regulation of attention and behavior during the reflective stage (Pickett & Gardner, 2005). The Social Monitoring System (SMS; see Pickett & Gardner, 2005 for an overview) involves selectively attending to social cues and maintaining behavior that is socially desirable. At its most basic level the SMS functions as a notification system that the current situation needs further evaluation by attending to social cues. The SMS is hypothesized to be sensitive to an individual's sense of belonging, however it can be compromised by social pain (Gardner et al., 2000; Picket & Gardner, 2005). Eisenberger and Lieberman (2004) suggest that the cognitive systems responsible for detecting social pain may deplete cognitive resources away from other cognitive systems that support monitoring. Targets that can use executive functioning to regulate social pain may be able to use the SMS effectively whereas those who cannot are susceptible to social pain and are less likely to use the SMS effectively. Recent empirical evidence gives support for Eisenberger and Lieberman's notion that social pain may compromise monitoring.

Ball (2011) explicitly tested the effects of ostracism on performance monitoring (a proxy for an individual's social monitoring ability). Performance monitoring impacts the degree to which individuals are accurate following errors (Themanson, Pontifex, & Hillman, 2008). Ball measured performance monitoring as the percentage of correct trials following an incorrect trial or error on a cognitive task (i.e., post-error accuracy). Results showed that ostracism negatively affects monitoring, as participants were less accurate after making an error following a game where they were socially excluded than prior to the game. Ball concluded that following ostracism cognitive resources are drawn away from cognitive systems that support executive functioning and are instead diverted to regulate the pain response.

Despite such findings, not all ostracized individuals exhibit cognitive impairment. For example, Gardner and colleagues (2000) found excluded participants remembered more social information than included participants. Also, several studies demonstrated participants adaptively respond by working harder on a collective task with others than an individual task following ostracism (Karau & Williams, 1993; Williams & Sommer, 1997). Such adaptive outcomes suggest there may be a capacity to regulate the cognitive effects of ostracism. A study conducted by Chester and colleagues (2013) found one maladaptive outcome of ostracism (e.g., aggression) may be a function of an individual's inherent executive functioning capacity. Individuals with high executive functioning capacity responded to ostracism with less aggressive behavior than those with low executive functioning capacity. Chester and colleagues (2013) concluded that social pain may increase or decrease maladaptive behavior depending on an individual's self-regulatory capability.

Enhancing executive functioning performance appears critical to counteract maladaptive outcomes of ostracism. Interventions designed to enhance executive functioning may regulate social pain and direct attention towards monitoring and behavior. Of particular interest is a growing body of literature that suggests we can enhance our executive functioning performance through acute bouts of physical activity. Accumulating evidence suggests that physical activity is beneficial for cognitive health and enhanced brain function (Chaddock, Voss, & Kramer, 2012;

Hillman et al., 2008). Chang and colleagues (2012) showed that the most robust benefits to executive functioning occur shortly after physical activity has ceased.

Acute aerobic physical activity is an attractive method to enhance executive functioning because it is a readily available, low-cost, and widely applicable pursuit (Kramer & Erickson, 2007). Several review papers and meta-analyses estimate that an acute bout of aerobic physical activity has a small to moderate positive effect on executive functioning as measured from pre- to post-exercise (Barenburg, Berse, & Dutke, 2011; Best, 2010; Chang et al., 2012; Lambourne & Tomporowski, 2010). In the most recent meta-analysis, Chang and colleagues (2012) found significant positive effects on executive functioning performance immediately and following a delay after the cessation of physical activity. For example, Pontifex, Hillman, Fernhall, Thompson, and Valentini (2009) found that young adults had shorter response times on an executive function task immediately following and 30 minutes after a 30-minute bout of aerobic physical activity when compared to pre-test response times. Furthermore, O'Leary, Pontifex, Scudder, Brown, & Hillman (2011) conducted a study examining the cognitive effects of acute bouts of physical activity via 20 minutes of treadmill walking with young adults. Treadmill walking was found to elicit significantly shorter response times than other non-aerobic activities and rest conditions.

Despite the growing body of literature supporting the benefits of physical activity on executive function, there is a need for research investigating the effect of acute bouts of physical activity on performance monitoring. In line with Chester and colleagues' findings (2013), improving executive functioning performance may aide in regulating the effects of ostracism and counteract maladaptive outcomes. Current physical activity research showing improvements to behavioral measures of monitoring is scarce for young adults. Monitoring is likely to benefit from acute bouts of physical activity because monitoring is dependent on executive functioning processes that are enhanced following physical activity. Whether physical activity can boost monitoring performance in situations where it is needed (e.g., events of ostracism) remains to be tested.

The purpose of this study was to investigate the cognitive effects of ostracism following an acute bout of physical activity. Investigating the effects of ostracism on executive functioning performance, such as monitoring, may aid in better understanding the cognitive effects of ostracism. Regulating the reflexive effects of ostracism may be of particular importance for reducing maladaptive behavioral outcomes (Ball, 2011; Chester et al., 2013). Therefore, pursuing methods to improve executive functioning performance as a means to aide regulation of the effects of ostracism is potentially worthwhile. Physical activity may serve such a purpose. The effects of physical activity on executive functioning may diminish the cognitive effects of ostracism. We tested the effects of ostracism on executive functioning performance following a 20-minute bout of treadmill walking. Given the absence of work on the combined effects of physical activity and ostracism on cognition, we approached this exploratory study with two questions: (a) What is the effect of exercise on executive functioning performance? (b) What is the combined effect of exercise and ostracism on executive functioning performance?

CHAPTER TWO

LITERATURE REVIEW

Social interactions influence how we think, feel, and behave. Of particular interest in the present study is a type of negative social interaction called ostracism. Ostracism is the process of ignoring or socially excluding others (Gruter & Masters, 1986; Williams, 2007a). Ostracism can be a traumatic event with behavioral, psychological, and emotional effects. Regulating the effects of ostracism is essential to cope and thoughtfully respond. This self-regulatory process is dependent on one aspect of cognition called executive functioning (Hofmann et al., 2012). One critical aspect of executive functioning salient to ostracism is the ability to monitor social information. Monitoring is essential for self-regulating behavior by attending to social cues and to ensure behavior does not interfere with intended goals (Baumeister & DeWall, 2005). Investigating aspects of executive functioning such as monitoring may aid in better understanding the cognitive and behavioral effects of ostracism. Additionally, exploring methods to enhance executive functioning has the potential to aide in regulating and diminishing the negative effects of ostracism. A worthy approach receiving recent attention is how acute bouts of physical activity may enhance executive functioning performance. Exploratory research endeavors are warranted to test whether physical activity can enhance executive functioning and aide in regulating or diminishing the effects of ostracism. This thesis represents such an endeavor.

There are three primary goals of this literature review. The first is to provide a theoretical framework for ostracism and its behavioral, psychological, and emotional effects. The second primary goal is to overview research showing physical activity to be beneficial for executive functioning. The final goal is to provide a rationale for exploring physical activity as a potential strategy to enhance executive functioning and aide in regulating the effects of ostracism.

Ostracism: Detection, Evolution, and the Temporal Model

Ostracism is the process of ignoring and social excluding individuals or groups by other individuals or groups (Williams, 2007a). All forms of ostracism involve a target (i.e., the victim) and the source (i.e., the perpetrators). Ostracism typically occurs for the target in an unpredictable fashion without excessive explanation or explicit negative attention (Williams, 2007a). An evolutionary rationale has been emphasized as the basis for understanding the effects of ostracism on humans because ostracism has been observed in most social species across time and cultures. Williams and Zadro (2005) demonstrate that animals who are ostracized face an early death. Animals who are ostracized for reasons of illness, injuries, or detrimental behaviors (e.g., fighting) are deprived of the pooled resources of the group. Without food, protection, and social interaction they most likely lag behind and ultimately die from attacks or starvation. Therefore, the ability to detect and respond to ostracism is a likely a crucial adaptive response to regain inclusion and avoid an inevitable death (Williams & Zadro, 2005).

The same evolutionary perspective exists for humans. Although Williams and Zadro (2005) recognize that some humans have survived in isolation, the occurrence of isolated humans surviving is far less frequent than that of humans in groups. Groups that ostracized non-fitting individuals formed a more cohesive bond with each other and created greater opportunities for security and reproduction (Williams, 2007a). Ostracism from this perspective is functional and adaptive for the group. Those members of the group were likely to be good at anticipating ostracism and adjusting behavior to respond to the event of being ostracized in an adaptive manner. These individuals who were successful at avoiding ostracism or regaining and maintaining inclusion were more likely to survive. Together this suggests that humans may have passed on or developed an ostracism detection system in response to any signals that hinted at ostracism (Williams, 2007a; 2007b; Williams & Zadro, 2005).

Humans most likely evolved in such a way that ostracism would result in an alarming response because the costs of not detecting ostracism would be high (Williams, 2007a). The hypothesized alarm signal to detect ostracism is the experience of pain. Ostracism results in directing attention towards the source of the pain and enabling behaviors to reduce or cope with the pain (Williams 2007a; Williams & Zadro, 2005). Williams and Zadro (2005) suggest that it would be maladaptive if humans displayed a wide array of responses to ostracism other than pain. Enduring ostracism without responding immediately would likely lead to devastating effects, similar to holding an extremely hot cup and not putting it down to relieve the pain.

There are a number of theories that detail the behavioral, psychological, and emotional effects of social exclusion, ostracism, and rejection. Williams (2007a; 2009) provides a temporal model that consists of events or stages that occur in a progressive sequence after an event of ostracism. The first event to occur is reflexive and includes the experience of social pain, a diminished sense of belonging, self-esteem, control, and meaningful existence needs, reduced positive affect, and increased negative affect. The reflexive stage is then followed by a reflective stage characterized by cognitive appraisals of the social situation in order to assess what happened and how to behave next. During the reflective stage the target of ostracism engages in coping strategies to reduce pain, restore a sense of the affected needs, and regulate emotion (Williams, 2007a).

The Reflexive Stage

An event of ostracism induces emotional, physical, and social pain (Smart Richman & Leary, 2009; Williams & Zadro, 2005). The involuntary pain response is evidenced by self-report measures of distress following ostracism and physiological measures of increased blood pressure (Williams, 2007a). Also, an event of ostracism results in increased neurological activation of a brain region associated with physical pain (Eisenberger, Lieberman, & Williams, 2003). The reflexive pain response serves to alarm the individual that there is a discrepancy between typical feelings and current feelings. Eisenberger and colleagues (2003) conclude that social pain from ostracism is analogous to experiencing physical pain, altering the ostracized individual that there is an injury to his/her social connections. Eisenberger and Lieberman (2004) suggest that the activation of the notification system responsible for detecting social pain is so cognitively demanding that it may deplete cognitive resources away from supporting other cognitive tasks. Such cognitive tasks may be necessary to regulate behavior following an event of ostracism (Hofmann et al., 2012). In addition to social pain, Williams (2009) suggests the effects of ostracism also stem from a diminished sense of four theoretical needs. Targets of ostracism commonly report a diminished sense of belonging, self-esteem, control and meaningful existence (Williams, 2007a; 2009)

Of the many different types of social interaction that can occur within groups, ostracism is unique in that it affects a victim’s sense of belonging. Baumeister and Leary (1995) suggest that feeling connected to others through social interaction is a fundamental need for all humans. Belonging is conceptualized as the need to form stabilized and strong interpersonal relationships that are positive, lasting, and significant (Baumeister & Leary, 1995). The need to belong is thought to have developed from the social and interdependent nature of human evolution whereby achieving a sense of acceptance and belonging with others is necessary for psychological and physical well-being (Baumeister & Leary, 1995; Smart Richman & Leary, 2009). Williams (2007b) maintains that ostracism threatens the need to belong more clearly than other negative social interactions. For example, when a person is ostracized it indicates a separation from the group rather than a verbal disagreement or heated argument. Williams and Zadro (2005) illustrate this concept when comparing the silent treatment (i.e., a form of ostracism) and a verbal argument. The silent treatment offers no way to effectively interact with others, indicating a clear separation that threatens the victim's sense of belonging. Verbal arguments involve an exchange or interaction with other individuals. This interaction may not as clearly threaten the victim's sense of belonging because there is not separation from other individuals. However, the need to belong is not entirely independent of other needs affected by ostracism. The need to belong is closely related the need for self-esteem.

How we perceive others to notice our goodness and worth is a core aspect of the need for self-esteem (Williams & Zadro, 2005). Much of the work investigating social exclusion and ostracism refers to Leary, Tambor, Terdal, and Downs's (1995) sociometer hypothesis. The sociometer hypothesis characterizes self-esteem as a system that "functions to monitor the degree to which in an individual is being included versus excluded by others and that motivates the person to behave in ways that minimize the probability of rejection or exclusion," (Leary et al., 1995, p. 518). Therefore, self-esteem is a proxy or gauge of how included or excluded the individual feels. Williams and Zadro (2005) suggest that ostracism threatens self-esteem more than other forms of interpersonal rejection because ostracism often occurs without explanation. Individuals are left to ruminate about what wrongdoings they did and must generate plausible reasons for why they were the target of ostracism. Reasons may include inappropriate behavior, meanness, and selfishness among others (Williams, 2009). In a verbal argument the cause of disagreement is explicit. The individual is only left to ruminate about the reason for the argument.

The need to perceive control over one's social environment is also affected following an event of ostracism (Williams & Zadro, 2005). Ostracism may evoke feelings of a lack of control because of the unpredictable and often silent nature of ostracism. Williams (2009) indicates that there is no efficacious response to ostracism compared to a physical or verbal altercation. The target cannot argue, discuss, or reason with the perpetrators because they do not respond. Their sense of social effectiveness with others is lost. As a result of a lack of perceived control, victims may become easily frustrated or angry and this can lead to self-destructive or aggressive behavior (Twenge, 2005; Williams, 2007a; 2009).

Self-destructive behavior such as emotional outbursts or inappropriate behavior may also be linked to the need for meaningful existence. Ostracism is a painful reminder of the victim's invisibility or that their existence is not recognized (Williams, 2007a). Williams and Zadro (2005) explain that ostracism for many cultures is one of the most extreme forms of punishment and translation of this punishment is closely linked with "social death." Ostracism may lead individuals to question their existence and in doing so they are reminded of death (Williams, 2007b). In comparing ostracism to a verbal argument, the victim of the verbal argument has someone to interact with and remind them of their existence, whereas with ostracism there is no one to interact with, indicating nonexistence. Williams (2007a) suggests that aggressive and anti-social behavior may be elicited by ostracism because these types of behavior are more likely than pro-social behavior to become recognized.

Behavioral consequences following an event of ostracism are hypothesized to be dependent on the needs that are most affected (Williams & Zadro, 2005). These behaviors serve to restore a sense of the affected needs and can range from being overly socially attentive to antisocial. If the belongingness and self-esteem needs are most affected then thoughts and behaviors are generally pro-social (Williams, 2009). People will behave in ways to restore their sense of belonging with others and may improve their chances of regaining inclusion. A study by Gardner and colleagues (2000) found that excluded participants remembered more social information compared to included participants. Furthermore, a pair of studies demonstrated participants adaptively respond by working harder on a collective task with others than working on an individual task following ostracism (Karau & Williams, 1993; Williams & Sommer, 1997). Increased attention to social information may provide an avenue for inclusion once ostracized. Ostracism may lead to behaviors that are characterized by increased social attention and interaction as a means to restore threatened belonging and self-esteem needs.

Contrary to pro-social findings, ostracism has been reported to lead to aggression, emotional numbness, poor self-regulation of behavior, and impairments in logical reasoning (Baumeister et al., 2007; Baumeister et al., 2005, Baumeister, Twenge, & Nuss, 2002). Participants who were told they would be socially excluded later in life ate more unhealthy snack foods than healthy snack foods, quit tasks requiring sustained attention sooner, and showed impaired attention on a listening task (Baumeister et al., 2005). These effects are hypothesized to be associated with the meaningful existence and control needs. People who have a diminished sense of meaningful existence or recognition along with a reduced sense of control may be more likely to act out to feel effective, which may escalate responses towards anti-social behavior. However, more research is needed to explicitly test if a diminished sense of meaningful existence and control needs are responsible (Williams, 2009).

The Reflective Stage

Following the experience of social pain and a diminished sense of belonging, self-esteem, control, and meaningful existence, targets of ostracism enter a stage of reflection. Attention is needed in response to the ostracism experience where the target can assess, appraise, and attribute the meaning and importance of the event (Williams, 2009). Targets are hypothesized to respond in a self-regulatory manner that will reduce pain and restore a sense of the affected needs through behavior and thoughts. The reflective stage includes monitoring social information and using that that information to self-regulate behavior by attending to social cues to ensure behavior does not interfere with intended goals (Pickett & Gardner, 2005). The reflective stage is susceptible to several moderators that may affect how victims respond such as the situational context and individual characteristics (Williams, 2009).

Individual characteristics may influence attention during the reflective stage which may explain the documented range of behaviors. Two commonly emphasized individual differences are social anxiety (Zadro, Boland, Richardson, 2006) and narcissism (Twenge, 2005). The speed of recovery may be affected by a target's trait level of social anxiety. Targets with high social anxiety tend to have longer recovery times from ostracism than those with low social anxiety (Zadro, et al., 2006). Those individuals high in social anxiety may spend more time attending to social information and may be more vulnerable to experiences of ostracism given that much concern is placed on social status and social relationships (Zadro et al., 2006). Another individual characteristic that may affect how a victim responds to ostracism is narcissism. Twenge (2005) highlights personality characteristics, such as narcissism, may moderate how individuals behave after an event of ostracism. Narcissists report being more angry and behave more aggressively than others in situations involving social rejection and exclusion. An event of social inclusion does not affect narcissists differently than others (Twenge, 2005).

Additionally, a number of contextual factors have been tested in the literature, such as distraction and group affiliation of sources of ostracism (Williams, 2007a; 2009). One important question is whether these contextual factors can bring about self-protective attributions to diminish or deflect the effects of ostracism (Williams & Zadro, 2005)? For example, if a victim is ostracized by out-group sources this may be easier to cope with when compared to being ostracized by in-group sources. Gonsalkorale and Williams (2007) tested this hypothesis for the immediate effects of ostracism and Gonsalkorale and colleagues (2008 as cited in Williams, 2009) tested this hypothesis for the effects of ostracism after a delay. Gonsalkorale and Williams (2007) found that there is no difference in the immediate effect of ostracism on negative affect and primary needs when victims were told they were ostracized by in-group (e.g., political party affiliation) compared to out-group perpetrators (e.g., KKK members, opposite political party affiliation). In a follow-up study, being ostracized by an in-group (e.g., similar political party affiliation) resulted in recovering from the ostracism experience slower than being ostracized by an out-group (e.g., KKK, opposite political party affiliation) when measured over time (Gonsalkorale et al., 2008 as cited in Williams, 2009). Furthermore, distracting individuals after an experience of ostracism can affect their coping and recovery over time (Swim & Williams, 2008 as cited in Williams, 2009). For those individuals who were distracted following ostracism, they recovered faster than those who were told to write about their current thoughts. However, ostracized individuals without distraction (e.g., the writing group) tended to recover from an experience of ostracism within a few seconds to a few minutes (Williams, 2009). The immediate effects (e.g., reflexive stage) of ostracism appear to be universal regardless of contextual factors, but after some time the speed of recovery during the reflective stage may be affected by group affiliation and distraction (Williams, 2009).

How an individual responds to an event of ostracism relies heavily on social information that the target monitors. Social monitoring is a complex cognitive and adaptive process involving the regulation of attention and behavior towards social cues (Pickett & Gardner, 2005). The Social Monitoring System (SMS; Pickett & Gardner, 2005) involves selectively attending to social cues and maintaining behavior that is socially desirable. Much emphasis has been placed on the need to belong as the motivating factor for individuals to monitor their social environment because information from the immediate social environment may provide clues for achieving acceptable levels of belonging. When an individual’s sense of belonging is threatened, this results in a heighten sensitivity to social information in order to restore the belonging need. The SMS is considered to be adaptive in that it allows individuals to become aware of social information that can be used to restore a sense of acceptance and connectedness with others if the need to belong is threatened. The sociometer hypothesis complements this theory as self-esteem serves as a means to gauge that a level of acceptance and belonging is being achieved (Leary et al., 1995). When an individual’s need to belong is threatened, the SMS is activated and serves as a notification to the target individual that the current situation requires further evaluation. This evaluation is composed of the target attending to social cues and surveying potential behavioral responses to avoid any negative consequences.

Ostracism is unique in that it involves a host of other effects (e.g., social pain) in addition to a diminished sense of belonging, which may compromise monitoring. Specifically for ostracism, Eisenberger and Lieberman (2004) suggest the activation of the notification system responsible for detecting social pain is so cognitively demanding that it may deplete cognitive resources away from supporting other cognitive tasks. Failure to effectively monitor information following an event of ostracism may be a result of experiencing social pain. Baumeister and colleagues (2005) label this cognitive deconstruction. They argue that the experience of social pain may be so cognitively demanding that impairments in cognition arise. Recent empirical evidence suggests that an event of ostracism results in impaired monitoring performance.

One study to date (e.g., Ball, 2011) has explicitly tested the effects of ostracism on a performance monitoring. Performance monitoring, or response monitoring, is the awareness of responses following the occurrence of an error in a cognitive task (Olvet & Hajcak, 2008). Performance monitoring measures the degree to which individuals are accurate following errors, which is a direct proxy of the ability to interact with the environment as with social monitoring (Themanson et al., 2008). The hypothesized cognitive systems are similar for error detection, SMS monitoring, and social pain. Detection of ostracism is likely a form of error-detection in the sense that the current social situation is different than before ostracism. Results showed that ostracism negatively affects monitoring. Participants were less accurate after making an error in the ostracism condition when compared to the inclusion condition. Ball concluded that following an experience of ostracism cognitive resources are drawn away from cognitive systems that support monitoring and are instead diverted to regulate the pain response. This result supports Baumeister and colleagues' (2005) cognitive deconstruction.

Cognitive impairments are found not just for monitoring performance, but also for performance in cognitive processes that may support monitoring. Jamieson, Harkins, and Williams (2010) found that ostracized participants were less accurate than included participants on a cognitive task that measured attention. This suggests that attention may be disrupted during the reflective stage. In a more recent study, Chester and colleagues (2013) tested the relationship between social pain stemming from ostracism, aggression, and cognitive self-regulation. Cognitive self-regulation was hypothesized as being responsible for regulating the effects of ostracism during the reflective stage. They found that ostracized individuals who performed worse on a cognitive task expressed more aggressive behavior than those who performed better on the task. Findings suggest that performance on this cognitive task reflects the ability to self-regulate the effects of ostracism (Chester et al., 2013; Hofmann et al., 2012). The results from Ball (2011) and Chester and colleagues (2013) suggest that cognition plays a crucial role during the reflective stage.

Manipulations of Ostracism

There are several different manipulations of ostracism and social exclusion used in this line of research. According to Williams (2007a) and Smart Richman and Leary (2009), the different manipulations themselves may account for range of ostracism's behavioral and emotional effects. The two paradigms receiving the most attention in the literature are the life alone paradigm and Cyberball. Bernstein and Claypool (2012) suggest that CyberBall offers the best exclusion paradigm that is useful in laboratory settings. There also exist several other manipulations that are not detailed below but include cell-phone text messaging, internet chat rooms, reliving or imagining rejection experiences, scenario descriptions of rejection and social exclusion, and individual versus dyadic tasks (see Williams, 2007a, for a more exhaustive list).

The life alone paradigm is an experimental manipulation created to make individuals feel excluded (Baumeister et al., 2002; Twenge et al., 2001). The life alone paradigm uses a personality test and gives true introversion or extroversion feedback and false feedback about a participant's future. There are three conditions with false feedback about a participant's future: (a) *future belonging* (b) *future alone* and (c) *misfortune control*. In the *future belonging* condition participants are told they are the type of person who will spend the rest of their life surrounded by people who care about them, have a long and stable marriage, and some lasting friendships. For the *future alone* condition, participants are told that they may have many friends at the present moment, which is common in university settings, but the test predicts the likelihood of ending up alone later in life. The friendships they currently have may drift apart and not be replaced, so he or she will spend more and more time alone. Finally, as a double control condition that does not involve belongingness but still a negative outcome, the *misfortune control* condition consists of feedback that participants would become increasingly more accident prone, requiring hospital visits for broken bones throughout life (Baumeister et al., 2002; Twenge et al., 2001; Williams, 2007a). The future of being alone manipulation stimulates anti-social behaviors and impairments in self-regulation and cognition (Baumeister et al., 2005; Baumeister et al., 2007; Baumeister et al., 2002). One short-coming of the life alone paradigm is that it does not elicit all of the specific theoretical effects of ostracism, and therefore may not specifically be ostracizing participants (Bernstein & Claypool, 2012).

The one paradigm that has been widely used to specifically evoke ostracism is Cyberball. Cyberball is an open-source virtual ball-toss game played on a computer (Williams & Jarvis, 2006; Williams, Yeager, Cheng, & Choi, 2012). Cyberball was designed to be more efficient, less traumatic, and easier to use in experimental settings than ostracism with actual people. Cyberball involves three players, one of which is the participant and two are computer-controlled confederates. Participants are told that they will be playing a virtual game of ball toss with two other undergraduate students over the university's network. As a cover story used to disguise the true purposes of the game, participants are told that this game has no intended goal and are asked to mentally visualize as if they are actually tossing a ball. A total number of 30 ball passes are fixed for the *inclusion* and *exclusion* conditions of the game (Williams et al., 2012). In the *inclusion* condition, the participant receives roughly one third of the passes. In the *exclusion* condition, the participant receives the ball only twice towards the beginning of the game, or about 7% of the time (Williams, 2007a). Results from studies using the Cyberball manipulation reveal that participants consistently report negative affect and a diminished sense of belonging, self-esteem, control, and meaningful existence needs (Williams, 2007a; 2007b; 2009). Most studies using the CyberBall manipulation have investigated psychological and affective components. Research efforts have steered away from comparing overt behavior following a game a Cyberball because Cyberball by design is used to evoke a mild form of ostracism and may not be traumatic enough the elicit overt behavioral effects.

Instead, one area gaining attention is how ostracism may affect cognitive processes that subserve self-regulation of behavior (Ball, 2011; Chester et al., 2013; Hofmann et al., 2012). A handful of studies have explored the cognitive effects of Cyberball. Although this research is in its infancy, accumulating evidence indicates that higher order cognition may be temporarily disrupted following a game of Cyberball (Ball, 2011; Chester et al., 2013; Jamieson et al., 2010). Aspects of higher order cognition, that subserve behavioral regulation, may be of particular importance during the reflective stage. Hofmann and colleagues (2012) suggest that executive functioning is an aspect of higher order cognition that is responsible for self-regulation.

Executive Functioning

Executive functioning is an umbrella term that represents an array of interrelated mental processes responsible for purposeful, goal-directed behavior (Gioia et al., 2001). These mental processes include selecting, initiating, implementing, and planning behavior. Executive functions require concentration or sustained attention and are used when relying on automatic behavior or instinct would be dangerous, inadequate, or impossible (Diamond, 2012). A number of related terms exist in the literature (Barkley, 2012). Executive control or cognitive control refers to the same top-down attentional processing in order to guide behavior to meet intentions or goals (Diamond, 2012; Miller & Cohen, 2001). The terms executive control and cognitive control are synonymous and refer to the same mental processing that occurs within the prefrontal cortex, an area that is highly correlated with executive functioning performance (Miller & Cohen, 2001). Executive functioning is categorized into three specific, yet related, components: inhibitory control, working memory, and cognitive flexibility (Diamond, 2012; Miyake et al., 2000).

Inhibitory control is the ability to actively control one's attention, behavior, thoughts, and/or emotions to override a strong mental or behavioral habitual tendency, and instead do what is more appropriate or needed at the given moment (Diamond, 2012). As a central feature of executive function, inhibitory control enables selection of a weaker relevant source of information over an otherwise stronger, but task-irrelevant one (Miller & Cohen, 2001). This feature at the level of perception is known as interference control (Diamond, 2012).

Inhibitory control is responsible for resisting impulsive behaviors such as shouting out an answer when it is more appropriate to raise your hand (Diamond, 2012). Inhibitory control makes it possible to change and choose how to react and behave. Without it impulsivity, conditioned responses, and environmental stimuli would rule behavior. Following an event of ostracism, individuals are presented with a load of information that requires inhibitory control. Targets of ostracism must inhibit the reflexive effects of ostracism while pursuing a more appropriate goal in order to regain inclusion. Adaptive responses are more cognitively challenging in that they require the ability to inhibit responses that would interfere with this process, regulate attention towards social cues, and use the information gathered from social cues to enact a behavior that would aide in regaining inclusion (Ochsner & Gross, 2005). Failure to inhibit the reflexive effects is likely due to temporary reductions in executive functioning leading to an inability to monitor and appraise the situation. However, human behavior is complex and cannot solely be reduced to one component of executive functioning. The influence of inhibitory control and working memory on behavior generally coexists and is more complementary than exclusive.

Working memory involves holding information in mind, where a stimulus for that information may no longer be present, and using that information to accomplish a goal or task (Diamond, 2012). Working memory is further categorized by the content of information held in mind, verbal working memory (i.e., phonological loop) and non-verbal working memory (i.e., visio-spatial sketch pad; Baddeley, 1992). For example, working memory is responsible for translating instructions into action, making sense of information that unfolds over time (relating what happened to what is to come), and updating information relevant to the current intended goal.

Working memory and inhibitory control generally occur together and rarely occur separately (Diamond, 2012). In order to concentrate on a piece of information, one must put aside all other competing pieces of information, and decide what is most relevant for that task. For example, a target of ostracism is gathering cues when monitoring. The target then is then tasked to use that information to behave while using inhibitory control to inhibit social pain. The inter-relatedness of these two components also extends to the third component of executive functioning, cognitive flexibility.

Cognitive flexibility is the ability to change perspectives or approaches to a problem while actively switching attention and behavior to adjust for new and ongoing demands, goals, or rules (Diamond, 2012). Cognitive flexibility is the most cognitively demanding component of executive functioning because it is the most complex and develops last out of the three components (Diamond, 2012). It relies heavily on a constant stream of information by utilizing working memory and inhibitory control to make quick or new adjustments to ongoing demands. Cognitive flexibility also includes specific processes such as switching or set-shifting. Switching or set-shifting represents the ability to change the way you answer a question based on changing information (Diamond, 2012).

There is evidence that inhibitory control, working memory, and cognitive flexibility performance are linked to mental health, physical health, quality of life, school success, and job success (Diamond, 2012). A longitudinal study that followed people from birth found lower childhood self-control (i.e., inhibitory control of behavior) predicted depression, poorer physical health, less financial success, and higher rates of criminal conviction by 32 years of age (Moffitt et al., 2011). Additionally, extensive research shows inhibitory control and working memory to be linked to academic achievement among children (Morrison, Ponitz, & McClelland, 2010). In a longitudinal study, children with higher performance on an array of measures of inhibitory control, working memory, and cognitive flexibility at 4 years of age were more proficient in math and reading when followed up at 7 years of age (Bull, Espy, & Wiebe, 2008). Furthermore, St Clair-Thompson and Gathercole (2006) found working memory to be associated with higher attainment in English and mathematics, while inhibitory control was associated with achievement in English, mathematics, and science in 11 to 12 year-old children. From a practical perspective, efforts to enhance the components of executive functioning may have important life consequences. Additionally, approaches to enhance executive functioning could diminish disruptions to cognition following an event of ostracism (Chester et al., 2013).

Physical Activity and Executive Functioning

A growing body of literature suggests executive functioning performance can be enhanced through acute bouts of physical activity. *Physical activity* is commonly defined as any muscular bodily movement that requires expending substantial amounts of energy (Caspersen, Powell, & Christenson, 1985). Accumulating evidence suggests that physical activity is beneficial for cognitive health (Chaddock et al., 2012; Hillman et al., 2008). More frequent physical activity has been linked to greater academic achievement, superior performance on tests of attention and memory, and enhanced brain function (Chaddock et al., 2012). Chang and colleagues (2012) have identified potential moderators of the physical activity and cognition relationship such as physical activity intensity and type, specific cognitive task types, and timing of the cognitive task. Physical activity and the term exercise are commonly used interchangeably, it should be noted that *exercise* is physical activity that is planned, structured, repetitive, and purposive (Caspersen et al., 1985). Therefore, acute bouts of physical activity can be considered exercise with the purpose to improve cognition.

For tasks measuring cognition after exercise, positive effects were found on tasks that measured attention, executive functioning, and intelligence (Chang et al, 2012). The effect of exercise on cognition was apparent when exercise was of light intensity, such as walking, or very hard intensity, such as running (Chang et al., 2012). Additional moderators that influenced the exercise and cognition relationship were studies that included both men and women using aerobic physical activity. The findings from Chang and colleagues (2012) regarding the positive effect of acute bouts of physical activity on cognition are consistent with earlier and more stringent meta-analyses investigating the exercise and cognition relationship (Lambourne & Tomporowski, 2010). As with all meta-analyses there is the potential influence of third order causation. Any of these moderators may be influenced from another moderator or a set of moderators. Therefore findings should be interpreted with caution. Accordingly, the present thesis is designed to measure cognition following exercise for light intensities.

Several review papers and meta-analyses suggest that an acute bout of aerobic physical activity has a small to moderate positive effect on executive functioning as measured from pre- to post-exercise (Barenburg et al., 2011; Best, 2010; Chang et al., 2012; Lambourne & Tomporowski, 2010). Following a 20-minute bout of treadmill walking, children displayed improvements in response accuracy compared to a sedentary condition on an inhibitory control task (Hillman et al., 2009). Pontifex and colleagues (2009) found that young adults had shorter response times on a working memory task immediately following and 30 minutes after a 30-minute bout of aerobic physical activity when compared to pre-test response times. O'Leary and colleagues (2011) conducted a study examining the cognitive effects of acute bouts of physical activity via treadmill walking with young adults. Treadmill walking was found to elicit significantly shorter response times without sacrificing accuracy.

Despite the growing body of literature supporting the benefits of physical activity on executive function, there is a need for research investigating the effect of acute bouts of physical activity on performance monitoring because findings are sensitive to the exact study design and protocol. Themanson and Hillman (2006) found no significant effects of single bouts of acute physical activity on behavioral measures of monitoring. A lack of statistically significant behavioral results may be attributed to the low difficulty of the cognitive task and the delay of cognitive assessment following the physical activity intervention. For example, accuracy scores for the cognitive task employed in the Themanson and Hillman study ranged from 91-94% and executive functioning performance was assessed on average 40 minutes after physical activity ceased. This finding is not surprising since most positive effects following an acute bout of physical activity are found after a short delay (Chang et al., 2012). The timing of assessing cognition may be important as more recent evidence suggests that improvements in response time and accuracy are observable following a single bout of acute physical activity when assessment occurs shortly after physical activity (e.g., Hillman et al., 2009; Pontifex et al., 2009). However, more work is needed to elucidate the behavioral effects of physical activity on monitoring.

Summary

Social interactions can influence how we think, feel, and behave. This literature review highlighted the psychological, emotional, and behavioral effects of ostracism. An area of research that has not received much attention is the effects of ostracism on executive functioning (Williams, 2007a; 2007b). Executive functioning is a set of cognitive processes necessary to regulate the effects of ostracism (Hofmann et al., 2012). Recent empirical evidence shows that executive functioning may be adversely affected following an event of ostracism (Ball, 2011). Therefore, it appears worthy to explore possible methods to enhance executive functioning prior to an event of ostracism. Enhancing executive functioning prior to an event of ostracism may assist with regulating the effects of this traumatic social experience and counteract cognitive disruption. A growing body of literature suggests acute bouts of physical activity can improve executive functioning performance (Chang et al., 2012; Hillman et al., 2008; Kramer & Erickson, 2007). Therefore, the purpose of this thesis is to test the cognitive effects of ostracism following an acute bout of physical activity.

CHAPTER THREE

METHODS

Participants

College-aged adults (*N* = 55) from undergraduate Kinesiology classes participated in the study. Participants were invited to participate through e-mail and an in-class presentation for an extra-credit incentive. Upon initial screening of those expressing interest in the study, two students were excluded who had contraindications for physical activity or had a history of neurological health issues, brain trauma, or concussion with loss of consciousness. Of the original sample of 53 participants, four dropped out of the study and one participant was removed due to extremely low performance on the cognitive task (< 50% accuracy). The final sample consisted of 48 participants (24 female). Participants identified as Asian (2.1%), African American or Black (8.3%), White (72.9%), mixed (10.4%), and other (6.3%). Most participants (89.6%) identified as being right handed and 33.3% reported using vision correction in the form of contacts or glasses. Participants reported accumulating enough METs per week for an estimated mean of 2.83 hours of strenuous, 2.17 hours of moderate, and 3.51 hours of mild physical activity per week. Table 1 contains demographic information for the sample.

Table 1
Demographic Information

Variable	*M* (*SD*)
Age	20.8 (2.4) years
Education	14.4 (1.6) years
BMI[a]	24.7 (3.4) kg/m^2
METs / week	187.8 (102.2)
Social Anxiety[b]	43.0 (19.8)

a. Indicates normal body composition
b. Possible mild social phobia

Research Design

A 3 x 3 within-subjects repeated measures design was used in this study (see Figure 1). A within-subjects design offers several advantages over between-subject designs. A within-subjects design controls for extraneous factors that have been identified to influence cognition such as intelligence, aerobic fitness, and socio-economic status (Chaddock et al., 2012; Hillman et al., 2008). It is more sensitive to the effects of each experimental condition because each

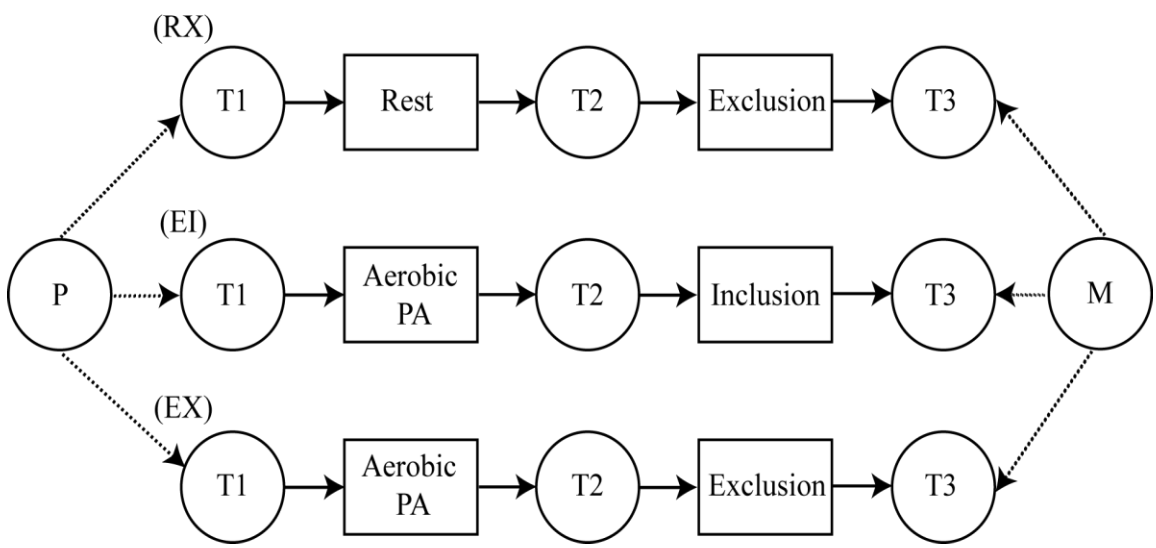

Figure 1. *Research Design.* A flowchart of the within-subjects repeated measures design. RX = rest and exclusion, EI = exercise and inclusion, EX = exercise and exclusion. Inclusion = inclusion Cyberball condition; Exclusion = ostracized Cyberball condition. P is the administration of the practice cognitive task only given on the first testing visit. T1, T2, T3 are administrations of the cognitive task. M represents retrospective questionnaires administered on the final day of testing.

participant's performance under one condition is compared to that participant's performance under another condition. Moreover, the design offers greater statistical power, requiring less time and fewer participants than a between-subjects design. After an initial scheduling visit, participants were randomly assigned to a counterbalanced sequence of conditions. Data collection occurred on three separate days within a mean window of 3.92 days (*SD* = 2.57) following their initial scheduling visit. Participants completed each of the testing visits at roughly the same time of day, with the mean bandwidth being 1.12 hours (*SD* = 1.59) apart. Only on the first testing visit did participants complete a practice cognitive task (P). Each testing day consisted of a baseline cognitive assessment (T1), a 20-minute physical or sedentary activity, a second cognitive assessment (T2), Cyberball, and a final cognitive assessment (T3). Condition RX consisted of a sedentary activity and the exclusion condition of Cyberball. Condition EI consisted of physical activity followed by the inclusion condition of Cyberball. Condition EX consisted of physical activity followed by the exclusion condition of Cyberball. On the third and final testing visit, a series of retrospective questionnaires (M) was administered. M specifically included the Needs Threat Scale, mood ratings, and an ostracism manipulation check to assess the effect of the ostracism manipulation for each experimental condition. This design enabled testing the effects of physical activity on cognition and the effect of physical activity and exclusion on cognition.

Assessments

Demographic and Health History Questionnaires. A demographic questionnaire was used to gather date of birth, age, education level, sex, race, and handedness. The health history questionnaire assessed history of conditions that may interfere with or become exacerbated by the study. These conditions include vision impairment, attentional disorders, asthma, epilepsy, and hospitalizations within the last 6 months to exclude participants with a history of brain injuries and disorders. The demographic and health history questionnaire (see Appendix A) was used in an attempt to only include healthy college-aged adults.

Physical Activity Readiness Questionnaire. Based upon guidelines recommended by the American College of Sports Medicine (2000), medical clearance from a personal physician to engage in acute physical activity is not considered necessary in healthy college-aged adults.

Instead, the completion of the Physical Activity Readiness Questionnaire (PAR-Q, Thomas, Reading, & Shephard, 1992) offers sufficient pre-activity screening to detect potential risk factors that might be exacerbated by acute physical activity. If participants answered "*yes*" to any of the six questions on the PAR-Q (see Appendix B), they would have been excluded from the proposed study. An example item from the PAR-Q asks "Do you have any unusual dizziness or fainting?"

Leisure-Time Physical Activity. General physical activity was assessed with the 3-item Godin Leisure-Time Exercise Questionnaire (LTEQ; Godin & Shephard, 1985). The measure assesses accumulated metabolic equivalents of task (METs) per a typical 7-day period (see Appendix C). A MET of 1 is equivalent to seated rest. Activities given a MET of 5 are considered to be five times as physically difficult as seated rest. Participants indicated how frequently during a typical week they engage in 15-minute sessions of strenuous, moderate, and mild exercise. The responses were then weighted with an appropriate MET value. The overall score of the LTEQ is an accumulated MET value calculated through the following formula: (strenuous x 9) + (moderate x 5) + (mild x 3). The 3-item sweat subscale was not employed for this study. Acceptable reliability and validity of LTEQ scores have been demonstrated in previous research among young adult and adult populations (Godin & Shephard, 1985; Jacobs, Ainsworth, Hartman, & Leon, 1993).

Social Phobia and Anxiety Inventory. The Social Phobia and Anxiety inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989) was employed to measure social anxiety (see Appendix D). Previous research using the SPAI shows the effects of ostracism can be influenced by an individual's level of social anxiety (Zadro et al., 2006). The SPAI assesses specific somatic symptoms, cognition, and behavior across a range of potentially fear producing situations. The

SPAI is a clinical measure of social anxiety that contains two subscales: social phobia and agoraphobia. The social anxiety score represents an overall indication of social anxiety by subtracting the agoraphobia subscale score from the social phobia subscale score. Tuner and colleagues (1989) suggest the necessity for using the difference is supported by empirical findings that there is much overlap among anxiety disorders, particularly between agoraphobia and social phobia. Using the difference between the two allows for a more accurate measure of social anxiety and removes potential overlap of social anxiety due to agoraphobia. The social phobia subscale of the SPAI contains 32 items and the agoraphobia subscale contains 13 items both rated on a 7-point Likert-type scale (1 = *never*, 2 = *very infrequent*, 3 = *infrequent*, 4 = *sometimes*, 5 = *frequent*, 6 = *very frequent*, 7 = *always*). Initial development of the social phobia and agoraphobia subscales indicate acceptable internal consistency scores of 0.96 and 0.85, respectively. Previous research indicates the SPAI is a valid measure of social anxiety (Peters, 2000). Reliability for the overall SPAI was 0.98 for the current study.

Physiological Assessments. Heart rate (HR), height, and weight were assessed. On the first visit to the laboratory, height and weight were recorded using a SECA Stadiometer (model 217) and Health O Meter scale (model HDL753DQ-95) following the completion of questionnaires. The PolarWearLink®+ 31 coded transmitter heart monitor (model RS400, PolarElectro, Finland) is a portable HR monitor containing an elastic cloth electrode strap and wireless clip-on transmitter. This PolarWearLink®+ 31 coded transmitter heart monitor allows for the real time measurement of HR sent to a wireless receiver. HR, which is an indication of intensity and energy expenditure during physical activity, was recorded every two minutes from the start until completion of each experimental condition. Age predicted HRmax was calculated by the formula (220 – years of age). All cognitive tasks were started when HR reached within 10% of the baseline HR that was measured at the beginning of each testing visit.

Cognitive Assessment. A modified version of the flanker task was employed to assess cognitive performance (Eriksen & Eriksen, 1974). This task has successfully been used in previous research (Ball, 2011; Hillman et al., 2009; Pontifex & Hillman, 2007). The modified version of the flanker task uses a central arrow instead of the original version which uses letters

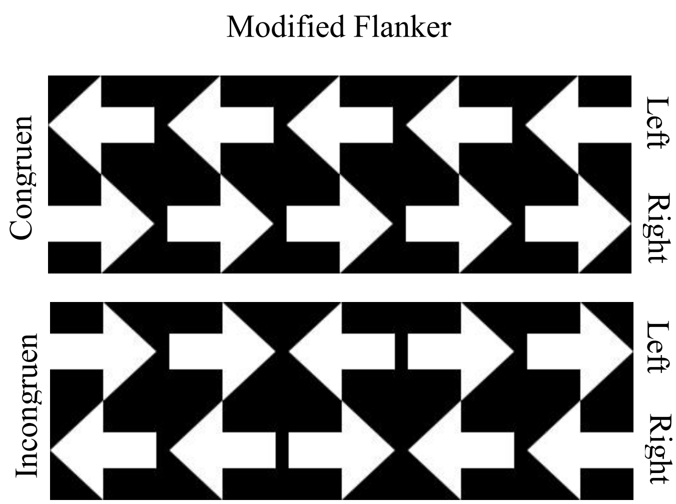

Figure 2. *Modified Flanker Stimuli* – a total of 300 trials were presented for each block of the modified flanker task.

(see Figure 2). The central arrow falls within an array of five total arrows. The central arrow either points in the same direction as all other flanking arrows (congruent) or points in the opposite direction of all other flanking arrows (incongruent). Incongruent stimuli evoke more errors and longer response times than congruent stimuli (Themanson et al., 2008).

Six-hundred trials administered in two blocks (300 per block) were pseudo-randomly presented on the screen for each cognitive assessment. Each trial consisted of an 80 ms display of the stimulus. Upon the onset of the stimulus participants were able to respond within a window of 1000 ms. However, this response window was shortened to 900 when the randomized inter-trial interval time was set to 900 ms and remained at 1000 ms when the inter-trial interval

Example Day in the Lab

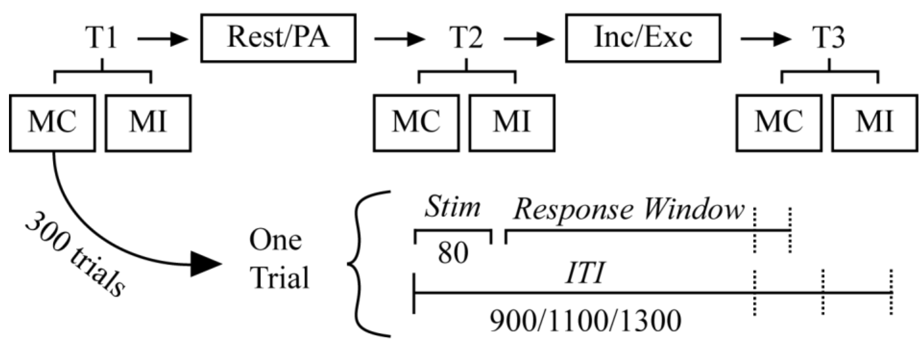

Figure 3. *Example Day in the Lab.* This figure represents an example day by each block and temporal breakdown of each trial. T1, T2, T3 = flanker task assessment time points, Rest/PA = rest or physical activity, Inc/Exc = inclusion or exclusion conditions, MC =mostly congruent, MI = mostly incongruent, Stim = stimulus time period, ITI = inter-trial interval. Numbers in one trial are in milliseconds.

was set to 1100 or 1300 ms (see Figure 3). A minimum threshold for responding was set at 100 ms so that participants' responses faster than 100 ms would be recorded as an error. Each inter-trial interval time of 900, 1100, and 1300 ms was equiprobable and randomized among trials. Presentation time and inter-trial interval time were reduced from previous studies in an effort to avoid a potential ceiling effect of accuracy on incongruent trials. The number of trials was increased from previous studies to observe more errors. A total of 1,800 stimuli were administered over the course of each testing visit to the laboratory. Stimuli were randomized into two compatibility blocks: mostly congruent (MC) and mostly incongruent (MI). The order of blocks was randomly assigned to participants and held constant for all administrations of the cognitive task. The MC block includes 30 incongruent and 70 congruent stimuli per every 100 stimuli. The MI block includes 70 incongruent and 30 congruent stimuli per every 100 stimuli. Participants were instructed to respond as quickly and as accurately as possible by pressing the left-most button on a response pad for a left pointing central arrow with the left thumb or the right-most button on a response pad for a right pointing arrow with the right thumb. Response times and accuracy on the modified flanker task were calculated. Additionally, post-error response time, post-error accuracy, post error matched correct response time, post error matched correct accuracy, and total number of commission errors were calculated (see Table 2 for definitions of these cognitive variables). The outcome of performance monitoring can be assessed through the accuracy and response time of a trial following an error of commission. PsychoPy version 1.76 was used to generate stimuli for the flanker task (Pierce, 2009).

Table 2. *Definitions of Cognitive Variables*

Variable	Definition
Response Time	Time in milliseconds recorded when a participant presses a button after a stimulus presentation is finished.
Accuracy	Percent of trials that a participant answered correctly by pressing the correct button within the response window.
Post-error Latency	The response time of a trial following an error of commission trial.
Post-error Accuracy	Accuracy following error of commission trials.
Post-matched-correct Latency	The response time of a trial following a correct trial. A correct trial is deliberately selected to be of similar response time or "matched" to an error of commission trial. †
Post-matched-correct Accuracy	Accuracy following correct trials. A correct trial is deliberately selected to be of similar response time or "matched" to an error of commission trial. †
Commission Errors	Errors made by pressing the incorrect button or by responding less than 100 ms after stimulus presentation.
Omission Errors	Errors made by not pressing a button within the response window.

† Controls for differences in response time between correct and error trials so that the only difference between the post-trials is that they followed a correct or error trial.

Needs Threat Scale. The Needs Threat Scale (Williams, 2009) is a theory-derived scale that assesses four fundamental needs: belonging, control, self-esteem, and meaningful existence (see Appendix E). Each subscale contains five questions for a total of 20 questions rated on a 5-point Likert-type scale anchored by 1 = *not at all* to 5 = *extremely* in relation to the CyberBall game. An example from the belonging subscale includes “I felt I belonged to the group;” the self-esteem subscale “I felt good about myself;” the meaningful existence subscale “I felt nonexistent;” and the control subscale “I felt I had control over the course of the game." The Needs Threat Scale was administered via computer on the final day of testing. Items were randomly intermixed among subscales in three orders for each visit to the lab. Participants responded to items from the most recent Cyberball game experienced, then the second Cyberball game on the second testing visit to the lab, and finally the first Cyberball game played on the first testing visit to the lab. Reliability analysis from an earlier version of the Needs Threat Scale (Zadro, et al., 2004) indicates internal consistency reliability values for subscale scores ranging from .66 to .74. The overall Needs Threat Scale was used due to low reliability of several of the subscales in the present study (i.e., < 0 .70). The overall Needs Threat Scale reliability ranged from 0.77 to 0.81 across testing visits.

Mood. Mood (see Appendix E) was assessed via a 7-item questionnaire that employs a 5-point Likert-type scale anchored by 1 = *not at all* to 5 = *extremely* (Williams, 2009). Participants retrospectively responded to how (1) good (2) bad (3) friendly (4) angry (5) pleasant (6) happy and (7) sad they felt during the CyberBall game. Items good, friendly, pleasant, and happy were averaged to create a positive mood index and the bad, angry, sad items were averaged to create a negative mood index (Wirth & Williams, 2009). The mood questionnaire was administered via computer on the final day of testing. Items were randomly intermixed in three orders for each visit to the lab. Participants responded to items from the most recent Cyberball game experienced, then the second Cyberball game on the second testing visit to the lab, and finally the first Cyberball game played on the first testing visit to the lab. The mood questionnaire has been used in previous research investigating the psychological effects of ostracism with acceptable reliability for the positive (α = .88) and negative (α = .87) mood indices (Williams, Cheung, & Choi, 2000; Wirth & Williams, 2009). Reliability across testing days in the present study ranged from 0.82 to 0.96 for the positive and 0.68 to 0.96 for the negative mood indices.

Manipulations

Physical and Sedentary Activity. During each physical activity condition, participants walked on a motor-driven treadmill for 20 minutes at a mean of 60% of their HRmax. Participants were given sufficient time to establish a walking pace. The treadmill incline was set at 1.0 and speed was increased every minute by the experimenter to ensure the 60% HRmax threshold was achieved during the first 5 minutes. Participants exercised at 60% HRmax in the remaining 15 minutes of treadmill walking. Previous research indicates treadmill walking is sufficient to enhance executive functioning performance (O'Leary et al., 2011). Participants watched a neutral video (Cooter, Holt, & Lachmann, 2011) directly ahead on a 40-inch television for 20 minutes while on the treadmill. During the sedentary condition, conversation was kept to a minimum and participants watched a neutral video on the same a 40-inch television while sitting for 20 minutes. A series of three 20-minute video clips from the neutral video were presented over the course of the three testing days.

Physical and Sedentary Activity Manipulation Check. As a manipulation check HR was averaged during the physical and sedentary activities in order to check if HR was at or above 60% of HRmax during the physical activity session.

Ostracism Manipulation. Cyberball 4.0 (Williams & Jarvis, 2006; Williams et al., 2012) is an open-source virtual ball-toss game that was used to evoke ostracism. Cyberball involves three players, one of which is the participant and two are computer controlled confederates. For purposes of this study, participants were told that they would be playing a virtual game of ball toss with two other undergraduate students over our network in between the second and third cognitive tasks. In reality, the other two players were computer controlled.

Participants were told that this game has no intended goal and were asked to mentally visualize as if they were actually tossing a ball. A total number of 30 ball passes was fixed for the inclusion and exclusion conditions (Williams et al., 2012). In the inclusion condition, the participant received roughly one third of the passes. Participants in the exclusion condition received the ball only twice, or about 7% of the time, within the first 10 throws. Cyberball has been used successfully in previous research to elicit feelings of ostracism (Ball, 2011; Van Beest & Williams, 2006; Williams et al., 2000; Zadro et al., 2004).

Ostracism Manipulation Check. A three item response questionnaire (Williams, 2009) served as a manipulation check for the ostracism manipulation (see Appendix F). Participants were asked to respond in line with their feelings during the game on a scale of 1-*not at all* to 5-*extremely*. Items 1 and 2 state "I was ignored" and "I was excluded," respectively. Item 3 asks for a percentage in response to the following question: "Assuming the ball should be thrown to each person equally (33% if three people), what percentage of throws did you receive?" The three-item manipulation check has been used in previous research (Ball, 2011; Zadro et al., 2004). After pilot testing the Cyberball game, pilot participants revealed that items on the manipulation check were revealing of the Cyberball game's true purpose. Therefore a decision was made to administer the ostracism manipulation check after the final testing visit and all other questionnaires were completed. Participants responded to items from the most recent Cyberball game experienced, then the second Cyberball game on the second testing visit to the lab, and finally the first Cyberball game played on the first testing visit to the lab.

Procedures

All participants were actively recruited from three Kinesiology classes. Students were introduced to research opportunities via an e-mail or an in-class presentation as part of an extra credit opportunity (see Appendix G). After expressing initial interest in the study via e-mail, participants were asked to visit the laboratory on four separate days. On the scheduling visit to the laboratory, participants were provided a detailed explanation of the purpose of the research (see Appendix H) and full informed consent information (see Appendix I). Participants were offered the opportunity to ask questions prior to providing written consent. Following the informed consent process, each participant was asked to complete a questionnaire packet containing the demographic and health history questionnaires, PAR-Q, LTEQ, and SPAI respectively. Height and weight were recorded after completion of questonnaires. Participants who met all inclusion criteria were invited to participate in the remaining three days of testing and were scheduled for the remaining visits. The scheduling visit lasted approximately 30 minutes.

Participants were told to come to the three testing sessions not having exercised earilier in the day and to not consume large amounts of caffeinated beverages. Participants were randomly assigned to a sequence of testing conditions (RX, EI, EX; EI, EX, RX; or EX, RX, EI) that were counterbalanced across participants (see Appendix J). Eighteen randomized flanker blocks were assigned and counterbalanced with two compatability orders (MC or MI as the first block), three flanker orders (ABC, BCA, & CAB) for assessment of the cognitive task (T1, T2, T3). Three 20-minute neutral video clips sequences were also counterbalanced in three orders (123, 231, & 312).

Upon arriving for each testing visit, participants were given a demonstration on how to properly fit a HR monitor and were escorted to a private area (bathroom) where the participant fit and put on the HR monitor. Then the participant sat at a desk for 2 minutes to obtain baseline HR. A run sheet and heart rate record were recorded in accordance to laboratory protocol and used to ensure the current participant received the proper counterbalanced sequences, the participant had consented to participate, date, time, the name of data files, accuracy on each task, baseline heart rate, 60% HRmax, 10% range in baseline HR, and HR every two minutes (see appendix K). The run sheet and heart rate record contained redundant information necessary for data integrity.

On all three testing visits participants were oriented to a monitor on a desk approximately 1 meter away to complete each flanker task. A leveled 24-inch monitor with a resolution of 1920x1080 and a refresh rate of 60 hertz displayed the flanker task stimulus consisting of all 5 arrows in white against a black background. Each flanker stimulus measured 4 cm tall, 12 cm wide, and was displayed in the center of the screen. Responses were recorded via a 4-Button Line-Pattern Button Box (Current Designs model TR-1x4-CR) that participants held in their hands. On the first testing visit, following the recording of pre-activity HR, participants completed a 50-trial practice session of the computerized flanker task (P). Each testing day subsequently started with two blocks of 300 trials of the flanker task which was used as a baseline cognitive task assessment (T1). Participants were instructed to respond as quickly and accurately as they can.

Following the baseline cognitive task assessment (T1), participants either participated in a physical or sedentary activity. During the sedentary condition, conversation was kept to a minimum and participants watched a neutral video (Cooter et al., 2011) on a 40-inch television for 20 minutes. During each physical activity condition, participants walked on a motor-driven treadmill for 20 minutes and watched a neutral video directly ahead on a 40-inch television for 20 minutes. Participants were given sufficient time to become oriented to the treadmill. Once oriented to the treadmill and provided a 5-minute period to gradually increase HR, participants maintained their HR at or above 60% of the age calculated HRmax for the remaining 15 minutes. The treadmill incline was set at 1.0 and speed was increased every minute by the experimenter to ensure the 60% HRmax threshold was achieved during the first 5 minutes. Following the cessation of treadmill walking, participants sat at a desk until HR returned to within 10% of pre-activity (baseline) levels. Then the second administration of the cognitive task (T2) began. Following completion of the second administration (T2), participants were oriented to a 15.4 inch laptop (Dell Vostro 3500) displaying the instructions of Cyberball. Participants were told to follow the instructions on screen while the experimenter read them out loud (see Appendix L). Following the completion of the Cyberball game, a final administration of the cognitive task (T3) began. HR was monitored to ensure all cognitive tasks were started while participants' HR was within 10% of their baseline recording. The first two testing visits lasted approximately 75 minutes. Following the final administration of the cognitive task (T3) during the final testing visit, the Needs Threat Scale and mood ratings were administered via computer. The ostracism manipulation check was administered via paper and pencil after the Needs Threat Scale and mood ratings were complete. Each participant responded to items retrospectively in relation to the most recent Cyberball game, then the second Cyberball game during testing visit two, and finally the first Cyberball game during testing visit one. Following completion of the experiement, participants were debriefed to the intended purposes of the research and the purpose of the CyberBall game. They were given the opportunity to ask questions. A debriefing and consent form to use data (see Appendix M) was provided to offer the participant an opportunity to discard their data or allow the researchers to use their data. The final day of testing lasted approximately 90 minutes.

Students received extra credit accounting for 2.5% of their grade in exchange for completing the full study protocol. There were alternative opportunities to earn extra credit in the course, including alternatives that do not require research participation and that require less time investment. These alternative methods of receiving extra credit included participation in a different experiment, writing assignments, and review assignments. This was designed to make the extra credit compensation for participation in this research non-coercive.

Data Analysis

IBM SPSS Statistics version 21 was used for data analysis. Descriptive statistics were computed for demographic variables of interest. Data were screened for outliers and systematically tested for their influence on all statistical models (Tukey, 1977). Internal consistency reliability values were calculated for each subscale of the Needs Threat Scale and the positive and negative mood indices. The SPAI total score was used as a covariate within all statistical models.

Mean HR was calculated as a manipulation check for the physical and sedentary conditions. Separate repeated measures ANOVA models were conducted to test experimental condition differences for each of the three Cyberball manipulation check items. Statistically significant models were separately tested for effects based on the order in which participants progressed through the study, compatibility blocks were received, flanker orders were received, and the movie segments were received. Post hoc *t* tests with Bonferroni correction were used to decompose significant effects when appropriate. A significance level of p = .05 was used for all analyses prior to Bonferroni correction.

Prior to analysis, items in the Needs Threat Scale were reversed scored where necessary and averaged (Zadro et al., 2006). Due to the low reliability of subscales, a global index score was computed by averaging all the items of the Needs Threat Scale. The positive and negative mood indices were computed by averaging the positively and negatively worded items, respectively. Separate repeated measures ANOVA models were conducted to test condition differences on the Needs Threat Scale and the positive and negative mood indices. Statistically significant models were separately tested for effects based on the order in which participants progressed through the study, compatibility blocks were received, flanker orders were received, and the movie segments were received. Post hoc *t* tests with Bonferroni correction were used to decompose significant effects when appropriate. A significance level of p = .05 was used for all analyses prior to Bonferroni correction.

Flanker task performance was analyzed in accordance with the a priori research questions. To test the effect of exercise on flanker task performance, separate 2 (Time 1 vs Time 2) x 3 (condition: RX vs EI vs EX) x 2 (compatibility: MC vs MI block) repeated measures ANOVA models were conducted. To test the effect of exercise and ostracism on flanker task performance, separate 2 (Time 1 vs Time 3) x 3 (condition: RX vs EI vs EX) x 2 (compatibility: MC vs MI block) repeated measures ANOVA models were conducted. Performance was averaged across the MC and MI blocks to compute a combined performance measure in response to failing to find a three-way interaction for time x condition x compatibility. All further statistical models used the combined performance measures. Accordingly, all statistical models used separate 2 (time) x 3 (condition) repeated measure ANOVAs. Statistically significant models were separately tested for effects based on the order in which participants progressed through the study, compatibility blocks were received, flanker orders were received, and the movie segments were received. Post hoc univariate ANOVAs with Bonferroni corrected *t* tests were used to decompose significant effects when appropriate. A significance level of $p = .05$ was used for all analyses prior to Bonferroni correction in accordance with previous research analyzing Flanker task data (Pontifex & Hillman, 2007).

Univariate effect sizes were computed using Cohen's *d* and multivariate effect sizes were computed using partial eta squared. Wilks' Lambda was used as the multivariate significance test statistic with a significance level set at $p < 0.05$.

CHAPTER FOUR

RESULTS

As shown in Figure 4, HR exceeded the 60% HRmax threshold (*M* = 119 BPM) for conditions EX and EI during exercise. HR was within 10% of baseline (*M* = 67 to 82 BPM) for each cognitive test for each condition. HR was also within the same 10% range for Cyberball.

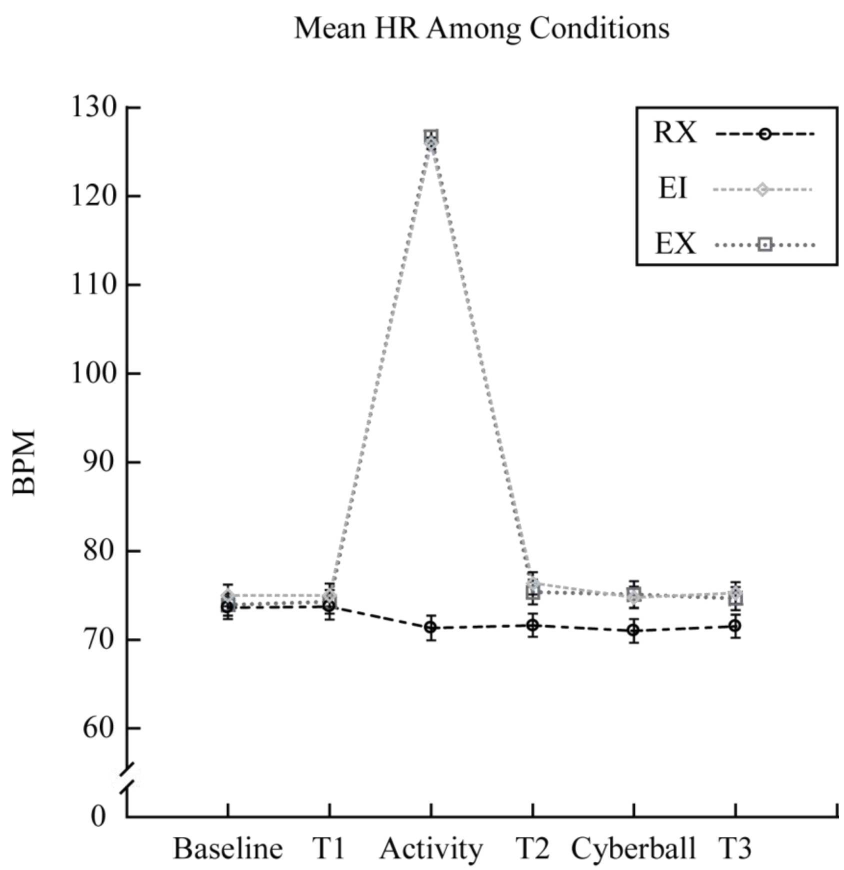

Figure 4. *Mean HR Among Conditions*. Error bars represent standard error of the mean. Baseline = baseline HR; T1, T2, T3 = flanker task assessment time points; Activity = rest/exercise activity; Cyberball = exclusion/inclusion conditions; RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion.

Separate omnibus analyses testing the effect of each experimental condition on the manipulation check for Cyberball revealed an effect for feeling ignored, $F(2,46) = 400.34$, $p < .001$, partial $\eta^2 = .95$, excluded, $F(2,46) = 526.02$, $p < .001$, partial $\eta^2 = .96$, and perceived

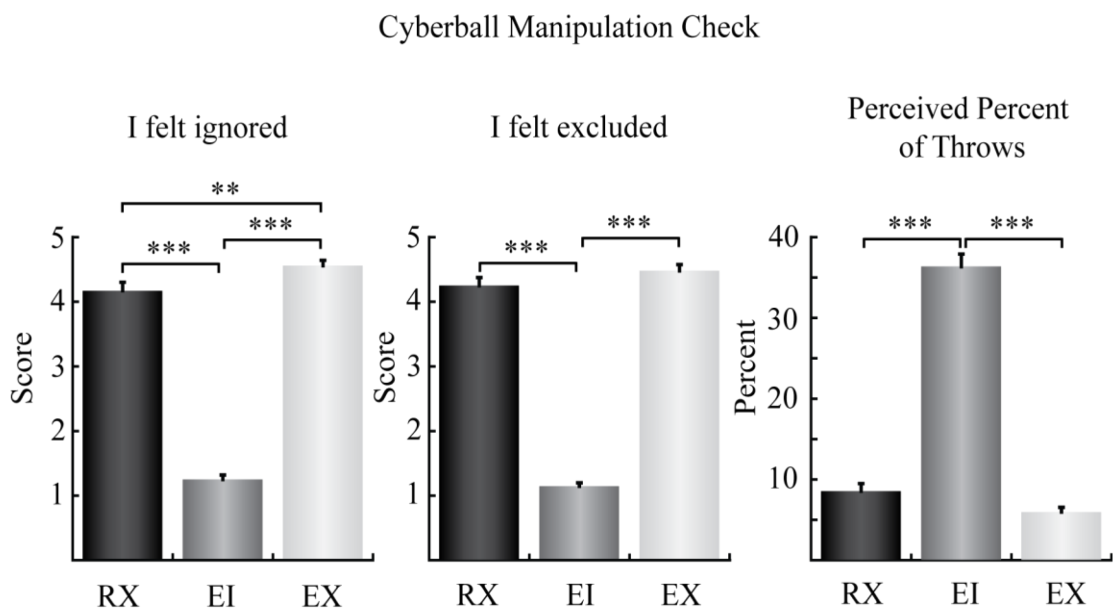

Figure 5. *Cyberball Manipulation Check.* Error bars represent standard error of the mean. RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion; *** $p < .001$; ** $p < .01$.

percent of throws received, $F(2,46) = 190.41$, $p < .001$, partial $\eta^2 = .89$. Post hoc pairwise comparisons with Bonferonni corrections ($\alpha = .017$) revealed participants reported feeling more ignored in RX than EI, $t(47) = 19.01$, $p < .001$, $d = 4.28$, less ignored in RX than EX, $t(47) = -2.79$, $p < .01$, $d = -0.50$, and more ignored in EX than EI, $t(47) = 28.58$, $p < .001$, $d = 6.19$. Participants reported feeling more excluded in RX than EI, $t(47) = 20.75$, $p < .001$, $d = 4.69$ and more excluded in EX than EI, $t(47) = 31.88$, $p < .001$, $d = 6.10$. Participants reported receiving fewer throws in RX than EI, $t(47) = -17.09$, $p < .001$, $d = -3.14$, and fewer throws in EX than EI, $t(47) = -19.63$, $p < .001$, $d = -3.76$. These effects were not influenced by any of the counterbalanced factors or social anxiety. Figure 5 illustrates the differences for each item on the Cyberball manipulation check.

Needs Threat

Reliability analysis for the Needs Threat Scale was poor for several of the subscales (α's < .70). within each condition, however reliability of the overall scale was deemed adequate (α = .77 to .81). The omnibus analysis revealed a condition effect, $F(2,46) = 124.54$, $p < .001$, partial $\eta^2 = .84$. Post hoc pairwise comparisons using Bonferroni correction (α = .017) revealed that scores for condition RX were significantly lower than EI, $t(47) = -15.52$, $p < .001$, $d = -3.98$, and

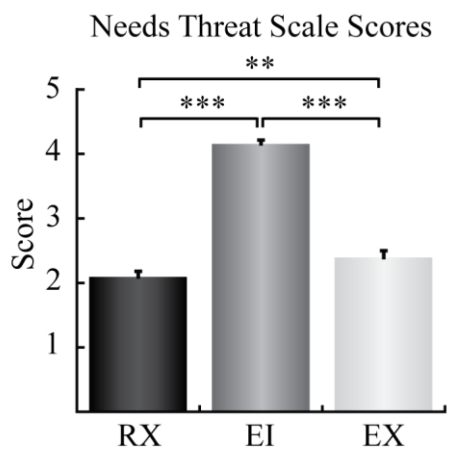

Figure 6. *Needs Threat Scale Scores.* Error bars represent standard error of the mean. *** $p < .001$; ** $p < .01$. Order effects not shown.

scores for condition EX were significantly lower than EI, $t(47) = -1.49$, $p < .001$, $d = -2.92$. Furthermore, scores for condition RX were significantly lower than EX, $t(47) = -1.49$, $p < .01$, $d = -0.44$. Figure 6 illustrates that condition RX had the lowest scores, indicating the highest need threat, followed by condition EX. However, follow-up analyses revealed a condition x order interaction, $F(4, 88) = 16.03$, $p < .001$, partial $\eta^2 = .42$, indicating that scores were influenced by the order participants progressed through the study. Deconstruction of this interaction using one-way ANOVAs revealed an effect of order on the EX condition, $F(2, 45) = 25.41$, $p < .001$, partial $\eta^2 = .53$. Participants who received EX on the first testing visit reported significantly higher scores on the Needs Threat Scale than participants who received EX on second testing visit, $t(30) = 8.49$, $p < .001$, $d = 3.10$, or third testing visit, $t(30) = 5.91$, $p < .001$, $d = 2.16$ after Bonferonni correction ($\alpha = .017$). No significant effects were found for conditions RX or EI. All needs threat models were not significantly influenced by any other counterbalanced factors or social anxiety.

Mood

Reliability analysis for the positive (α's = .82 to .96) and negative (α's = .68 to .96) mood indices were deemed acceptable across all conditions. The omnibus test revealed an effect of

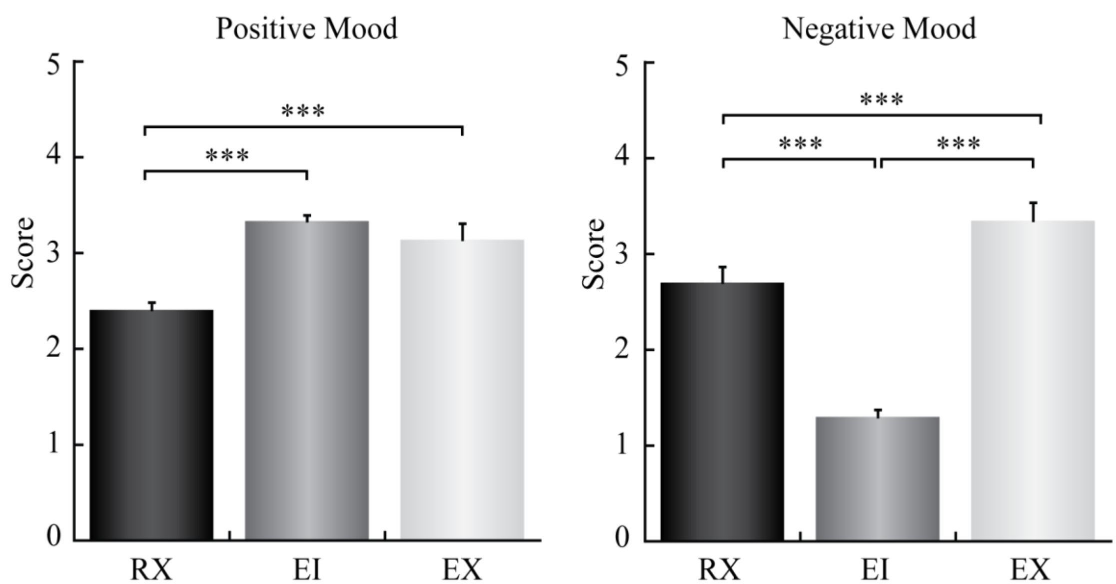

Figure 7. *Positive and Negative Mood*. Error bars represent standard error of the mean. RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion; *** $p < .001$. Order effects not shown.

condition, $F(2,46) = 48.22$, $p < .001$, partial $\eta^2 = .68$, on positive mood (see Figure 7). Post hoc pairwise comparisons using Bonferroni correction ($\alpha = .017$) revealed participants reported feeling less positive in condition RX than EI, $t(47) = -9.79$, $p < .001$, $d = -1.98$, and EX, $t(47) = -$

4.00, $p < .001$, $d = -0.83$. Positive mood scores for condition EX was not significantly different than EI, $t(47) = -1.10$, $p = .28$. However, these effects were superseded by a condition x order interaction, $F(4, 88) = 23.28$, $p < .001$, partial $\eta^2 = .51$. Deconstruction of this interaction using one-way ANOVAs revealed an effect of order on positive mood for the EX condition, $F(2, 45) = 64.13$, $p < .001$, partial $\eta^2 = .74$. This effect was driven by participants who received EX on the first testing visit. They reported significantly higher positive mood than participants who received EX on second testing visit, $t(30) = 8.64$, $p < .001$, $d = 3.15$, and third testing visit, $t(30) = 9.66$, $p < .001$, $d = 3.53$, after Bonferroni correction. Order did not significantly affect positive mood for condition RX or EI (p's > .15). All positive mood models were not significantly influenced by any other counterbalanced factors or social anxiety.

The omnibus test revealed an effect of condition, $F(2,46) = 52.28$, $p < .001$, partial $\eta^2 = .69$, on negative mood (see Figure 7). Post hoc pairwise comparisons using Bonferroni corrections ($\alpha = .017$) revealed that participants reported feeling more negative in RX than EI, $t(47) = 7.69$, $p < .001$, $d = 1.58$, more negative in EX than RX, $t(47) = 3.68$, $p < .001$, $d = 0.52$, and more negative in EX than EI, $t(47) = 10.11$, $p < .001$, $d = 2.08$. Figure 7 illustrates that participants reported having the most negative mood in condition EX, followed by condition RX, and the least negative mood in condition EI. However, the effects on negative mood were superseded by a condition x order interaction, $F(4, 88) = 13.50$, $p < .001$, partial $\eta^2 = .38$, indicating that negative mood scores were influenced by the order participants progressed through the study. Deconstruction of this interaction using one-way ANOVAs revealed an effect of order on negative mood for the EX condition, $F(2, 45) = 64.13$, $p < .001$, partial $\eta^2 = .74$. This effect was driven by participants who received EX on the first testing visit. They reported significantly higher negative mood than participants who received EX on second testing visit, $t(30) = 4.81$, $p < .001$, $d = 1.76$, and third testing visit, $t(30) = 5.41$, $p < .001$, $d = 1.98$, after Bonferroni correction. Order did not significantly affect negative mood for condition RX or EI (p's > .86). All negative mood models were not significantly influenced by any other counterbalanced factors or social anxiety.

Flanker Task Performance

No significant effects were found for mean response time from Time 1 to Time 2 (p's > .40). The omnibus test revealed a time x condition effect on flanker task performance for overall accuracy, $F(2,46) = 4.63$, $p < .05$, partial $\eta^2 = .17$, from Time 1 to Time 2 (see Figure 8). Post hoc pairwise comparisons using Bonferroni corrections ($\alpha = .017$) revealed the time x condition effect was driven by condition EX from Time 1 to 2, $t(47) = -3.58$, $p < .001$, $d = 0.32$, indicating exercise is beneficial for response accuracy from Time 1 to Time 2 only for condition EX. However, results should be interpreted with caution because response accuracy effects were superseded by a time x condition x order effect, $F(4,88) = 9.96$, $p < .001$, partial $\eta^2 = .31$. Three tests adjusted for multiple comparisons using Bonferroni corrections ($\alpha = .017$) revealed that EX from Time 1 to Time 2 effect was only found for participants who received EX on the first testing visit, $F(2,14) = 10.25$, $p < .001$, partial $\eta^2 = .59$. Models examining order for participants who received RX or EI on the first testing visit were not significant. These models were not significantly influenced by any other counterbalanced factors or social anxiety. Table 3 contains the mean values for overall accuracy for all time points.

In order to observe post error behavior, participants had to have at least six errors as a minimum threshold (Pontifex et al., 2010). The subsample ($n = 43$) of participants who made six or more errors were included in post error behavior analyses. The omnibus test revealed a time x condition effect for post error accuracy, $F(2,41) = 3.80$, $p < .05$, partial $\eta^2 = .16$, from Time 1 to Time 2. This effect was not found for post matched correct accuracy indicating this effect was unique to error trials. Deconstruction of the post error accuracy interaction adjusted for multiple -

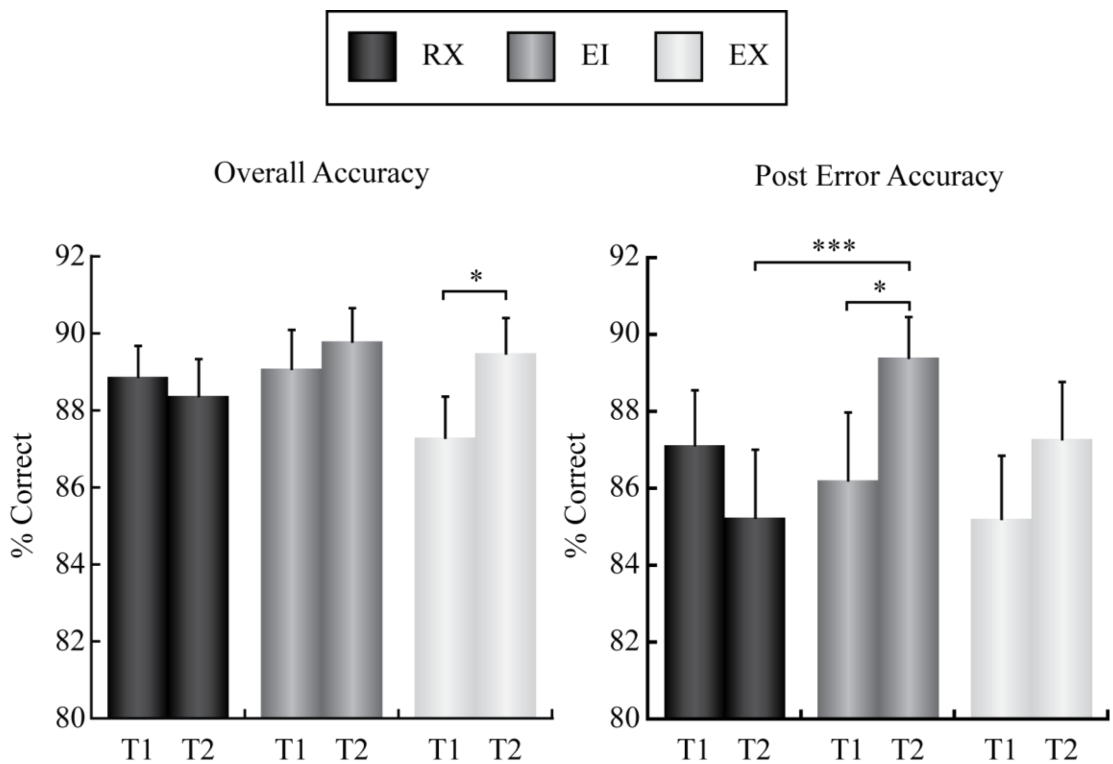

Figure 8. *Flanker Task Performance from Time 1 to Time 2*. Graphs show the effect of exercise on overall accuracy and post error accuracy. Error bars represent standard error of the mean. RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion; T1 = assessment at Time 1; T2 = assessment at Time 2; *$p < .05$; *** $p < .001$. Order effects not shown.

comparisons using Bonferroni corrections ($\alpha = .017$) revealed that the time x condition effect was driven by condition EI from Time 1 to 2, $t(47) = -2.53$, $p < .05$, $d = 0.34$, and the difference between RX and EI at Time 2, $t(47) = -2.89$, $p < .01$, $d = 0.49$. These analyses indicate that exercise was beneficial for post error accuracy from Time 1 to Time 2 in condition EI and more accurate at Time 2 than rest. However, results should be interpreted with caution as post error accuracy effects were superseded by a time x condition x order effect, $F(4,78) = 7.27$, $p < .001$, partial $\eta^2 = .27$, indicating that performance was influenced by the order participants progressed through the study. Three tests adjusted for multiple comparisons using Bonferroni corrections ($\alpha = .017$) revealed that this effect was driven by participants who received EI on the first testing visit, $F(2,12) = 8.63$, $p < .01$, partial $\eta^2 = .59$, and participants who received EX on the first testing visit, $F(2,13) = 11.28$, $p < .001$, partial $\eta^2 = .63$. Post hoc analyses reveal that for those participants who received EI on the first testing visit, participants only showed improvement from Time 1 to Time 2 in condition EI, $t(13) = -3.09$, $p < .01$, $d = 1.32$. For those participants who received EX on the first testing visit, participants only showed improvement from Time 1 to Time 2 in condition EX, $t(14) = -4.21$, $p < .001$, $d = 1.54$. The model examining the effects of time x condition for participants who received RX on the first testing visit was not significant. These results indicate that post error accuracy can be improved through exercise on the first testing visit (EI and EX), but exercise effects on any of the later testing visits are inconsistent (stable for EI but unstable for EX). All post error accuracy models were not significantly influenced by any other counterbalanced factors or social anxiety. Figure 8 displays overall accuracy and post error accuracy measures from Time 1 to Time 2 by condition. Table 3 contains the mean values for post error accuracy for all time points.

A repeated measures ANOVA revealed a main effect of time for post error latency from Time 1 to Time 2, $F(1,42) = 11.84$, $p < .001$, partial $\eta^2 = .22$. This effect indicates participants responded faster after making an error from Time 1 ($M = 381.9$ ms, $SD = 38.3$ ms) to Time 2 ($M = 373.6$ ms, $SD = 34.4$ ms) regardless of which condition they were in. This effect was not found for post matched correct latency suggesting that these effects are unalsmique to error trials.

Furthermore, the effect of time on post error latency was not influenced by any counterbalanced factors or social anxiety.

Figure 9 depicts the changes in time from Time 1 to Time 3 examining the effect of exercise and ostracism on overall accuracy and post error accuracy. No significant effects were found for mean response time from Time 1 to Time 3 (*p*'s > .40). The omnibus test revealed no significant main or time x condition effects for overall accuracy, $F(2,46) = 2.05$, $p > .13$, partial

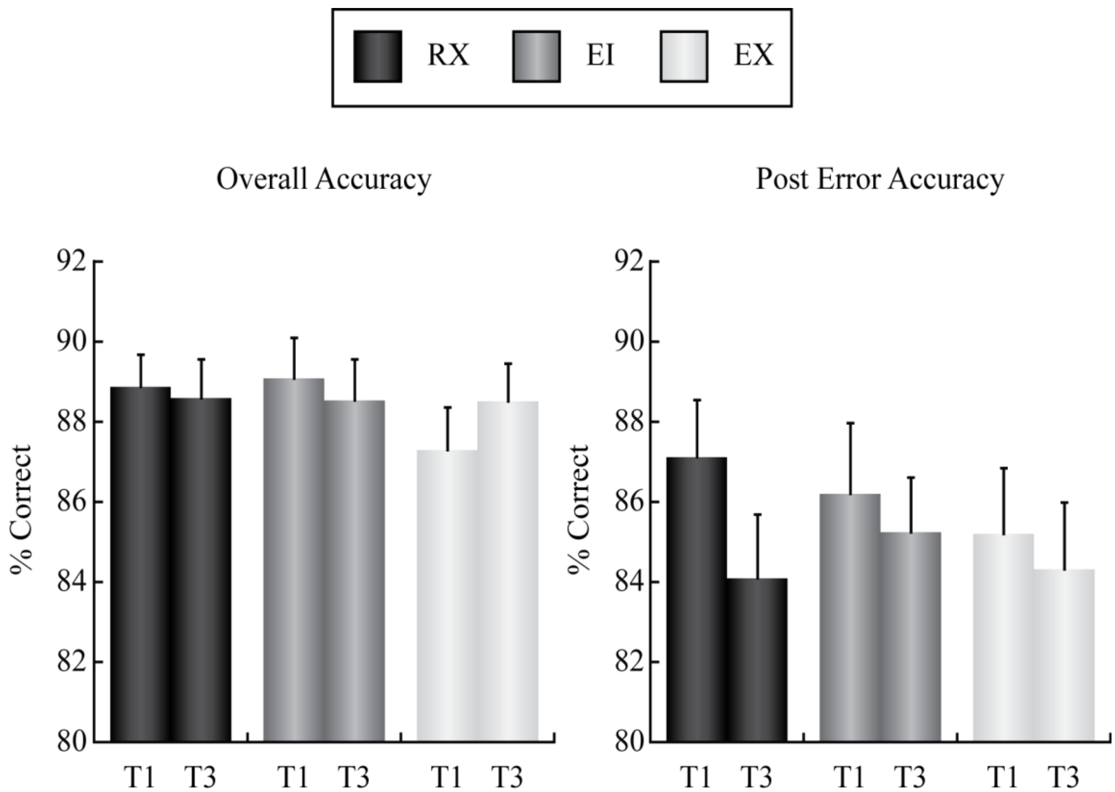

Figure 9. *Flanker Task Performance from Time 1 to Time 3.* Graphs show the effect of exercise and ostracism on overall accuracy and post error accuracy. Error bars represent standard error of the mean. RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion; T1 = assessment at Time 1; T3 = assessment at Time 3. Order effects not shown.

$\eta^2 = .08$. However, response accuracy effects were superseded by the order in which participants progressed through the study, $F(4,88) = 10.83$, $p < .001$, partial $\eta^2 = .33$. Three tests adjusted for multiple comparisons using Bonferroni corrections ($\alpha = .017$) revealed that this effect was driven by participants who received EI on first testing visit, $F(2,14) = 7.16$, $p < .01$, partial $\eta^2 = .51$, and EX on the first testing visit, $F(2,14) = 10.25$, $p < .001$, partial $\eta^2 = .51$. These models revealed that participants had higher accuracy on the second and third testing visits than on the first testing visit (*p*'s < .01) indicating a possible practice effect. No such relationship was found for participants who received RX on the first testing visit. Furthermore, all Time 1 to Time 3 overall accuracy models were not influenced by any counterbalanced factors or social anxiety. Table 3 contains the mean values for overall accuracy for all time points.

For the post-error accuracy subsample ($n = 43$), the omnibus test revealed no significant main or time x condition effects for post error accuracy from Time 1 to Time 3, $F(2,41) = 0.95$, $p = .40$, partial $\eta^2 = .04$. However, post error accuracy effects were superseded by the order in which participants progressed through the study, $F(4,78) = 3.66$ $p < .01$, partial $\eta^2 = .16$. This effect was also found for post matched correct trials, $F(4,78) = 5.30$, $p < .01$, partial $\eta^2 = .22$, suggesting this effect was not unique to error trials. Furthermore, all Time 1 to Time 3 post error accuracy models were not influenced by any other counterbalanced factors or social anxiety. Table 3 contains the mean values for post-error accuracy for all time points.

A repeated measures ANOVA revealed a main effect of time for post error latency from Time 1 to Time 3, $F(1,42) = 6.25$, $p < .05$, partial $\eta^2 = .13$. This effect indicates participants responded faster after making an error from Time 1 (M = 381.9 ms, SD = 38.3 ms) to Time 3 (M = 373.7 ms, SD = 33.1 ms) regardless of which condition they were in. This effect was not found for post matched correct latency suggesting that these effects are unique to error trials.

Furthermore, the effect of time on post error latency was not influenced by any counterbalanced factors or social anxiety.

Table 3. *Mean Values for Cognitive Data*

	T1		T2		T3	
Variable	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Accuracy						
RX	88.9	(5.5)	88.4	(6.7)	88.6	(6.7)
EI	89.1	(7.0)	89.8	(6.0)	88.5	(7.1)
EX	87.3	(7.4)	89.5	(6.4)	88.5	(6.5)
Post-error Accuracy						
RX	87.1	(9.4)	85.2	(11.6)	84.1	(10.0)
EI	86.2	(11.6)	89.4	(6.9)	85.2	(9.0)
EX	85.2	(10.8)	87.3	(9.7)	84.3	(11.0)

Note. RX = rest and exclusion; EI = exercise and inclusion; EX = exercise and exclusion. Data are percentages of correct trials.

CHAPTER FIVE

DISCUSSION

Interventions designed to counteract the effects of ostracism have rarely been examined in experimental research. The current study used an acute bout of physical activity, shown to enhance executive functioning, as a strategy to counteract cognitive disruptions of ostracism. Findings replicate previous work showing ostracism results in threats to primary needs and increased negative affect in support of the temporal need threat model (Williams, 2009; Williams et al., 2000; Wirth & Williams, 2009; Zadro et al., 2004). Consistent with previous research on physical activity and executive functioning, exercise was not detrimental and at times beneficial to executive functioning and monitoring performance (Hillman et al., 2009; O'Leary et al., 2011; Pontifex et al., 2009). However, ostracism did not impair executive functioning when receiving physical activity or rest. This may be due to several factors that are related to the ordering effects observed in the psychological and cognitive analyses, the exposure to cognitive task, and the design of the study. While it remains unclear if and precisely how ostracism affects executive functioning in college-aged young adults, the psychological and emotional effects appear to be consistent with previous research (Williams, 2007a).

Manipulation Checks

Manipulation check results showed that participants achieved the 60% HR max threshold for both exercise conditions. HR was within the same 10% range of baseline for both exclusion and inclusion conditions of Cyberball. Cyberball appears to not elicit a strong physiological response for HR despite previous research indicating that ostracism is related to increased levels of blood pressure and neurological activation of a brain region associated with physical pain (Eisenberger et al., 2003; Williams, 2007a). This finding is not striking since Cyberball was designed to elicit a mild form of ostracism and to be less traumatic than ostracism in other contexts (Williams & Jarvis, 2006; Williams et al., 2012).

The ostracism manipulation check results showed that participants reported feeling more ignored and more excluded during both exclusion conditions than the inclusion condition. Participants also reported receiving less throws in both exclusion conditions than the inclusion condition. These findings are in line with previous research confirming that Cyberball is a useful paradigm in experimental settings to ostracize participants (Williams, 2007a; Williams et al., 2000). Interestingly, participants reported feeling more ignored in the exercise and exclusion condition than in the rest and exclusion condition. This was the only difference found among these two conditions for the manipulation check. This may be an unintended consequence of exercising before an event of ostracism. Exercise could have made participants more attentive towards the Cyberball game when they were excluded, thereby making the event of ostracism more salient.

Psychological and Emotional Effects

In support of Williams' (2007a; 2009) temporal need threat model, participants reported lower needs threat scores in both exclusion conditions compared to the inclusion condition. Additionally, the rest and exclusion condition resulted in lower positive mood and higher negative mood than the inclusion condition. These differences are in line with previous research, suggesting that an event of ostracism threatens primary needs and has emotional consequences (Williams, 2007a; 2007b). Differences between the exercise and exclusion condition and the rest and exclusion condition existed for the Needs Threat Scale, positive mood index, and negative mood index. Participants reported the greatest overall need threat in the rest and exclusion condition, despite participants feeling the most ignored in the exercise and exclusion condition.

The group of participants who received exercise and exclusion on the first testing visit reported higher scores (i.e., indicating low need threat) than those participants who received this condition on the second and third testing visits. Similarly, this group reported higher positive mood and higher negative mood than participants receiving the exercise and exclusion condition on a later testing visit. These findings are likely confounded by the order in which participants progressed through the study. This makes the primary needs and mood findings difficult to interpret. One possibility is that when participants recalled each Cyberball game, exercise and exclusion threatened primary needs and had emotional consequences when participants received a prior inclusion condition. Thus, during the study participants may have needed a relative condition to compare the effects of ostracism for exercise and exclusion to have an effect. Another possibility is that exercise and exclusion may have the same effects on primary needs and mood as rest and ostracism, but this group of participants may have misinterpreted the impact of ostracism during the recall. For example, this group reported high positive mood and high negative mood which could suggest that this group of participants was responding without properly interpreting the questions.

The use of a global Needs Threat Scale score prevents understanding of the effect of an acute bout of physical activity on specific needs. Williams' (2007a; 2009) temporal need threat model suggests specific needs moderate the relationship between ostracism and its related outcomes. Unfortunately, this was not possible to interpret because of the low reliability of the subscales of the Needs Threat Scale. Low reliability of subscales is not uncommon. Previous research reports reliability values of subscales as low as 0.60 to 0.66 (Smith & Williams, 2004; Zadro et al., 2004) and researchers commonly use a global Needs Threat Scale score by averaging the items of the four subscales (Jamieson et al., 2010; van Beest & Williams, 2006;

Wirth & Williams, 2009). The present findings generally support Williams' (2007a) temporal need threat model that ostracism threatens primary needs and has emotional consequences. However, whether an acute bout of physical activity diminishes the effect of ostracism on belonging, self-esteem, control, and existence needs remains unclear.

Social anxiety appeared to have no influence on primary needs and mood for either exclusion condition compared to the inclusion condition. This may be because participants were not from a clinical population. Previous research showed that individuals with high social anxiety may be more sensitive to the effects of ostracism (Zadro et al., 2006). Most participants in the present study were classified as having possible mild social phobia. Given that participants visited the lab on four separate occasions, a rapport was most likely established and may have reduced the impact of social anxiety on the effects of ostracism.

Exercise and Ostracism Effects on Cognition

Exercise was selectively beneficial for inhibitory control and monitoring performance, partially supporting previous literature suggesting acute bouts of physical activity are beneficial for executive functioning and cognition (Barenburg et al., 2011; Best, 2010; Chang et al., 2012; Lambourne & Tomporowski, 2010). However, no effect was found for mean response time. Participants may have emphasized accuracy over response time, despite being instructed to respond as quickly and accurately as possible. The beneficial effect of exercise on cognition was only found for the exercise and exclusion condition for overall accuracy and the exercise and inclusion condition for post error accuracy. Although mean values were in the expected direction to support a beneficial effect of exercise for both accuracy and post error accuracy, interpretation is limited because these effects were dependent on the order in which participants progressed through the study. The finding that the order significantly influenced the effect of exercise on cognition suggests that the effects of exercise on cognition may vary when repeatedly measured.

The ordering effect showed minimal benefits of the exercise manipulation on later testing visits because participants were performing better on the second and third testing visits than on the first testing visit. Elevated performance is most likely due to repeated exposure to the cognitive task. As participants became more familiar with the task they tended to do better. On testing visits two and three it is possible that exercise was not powerful enough to overcome these practice effects. Therefore, there may have been minimal room to observe an exercise effect (on the second and third testing visits) given that participants were performing well.

Ostracism did not affect inhibitory control and monitoring performance. Analyses revealed no significant differences among the three experimental conditions. This may also be because of the repeated exposure to the cognitive task. One possibility is that ostracism was not powerful enough to overcome the practice effects of the cognitive task. This is not surprising, given that Cyberball was designed to elicit a mild form of ostracism. Another possibility is that ostracism may not disrupt cognition, but undermine the effect of physical activity on cognition. This was unable to be tested because the effects of an acute bout of physical activity on cognition may be short lived. The effect of physical activity on cognition was captured at the second assessment but not the third assessment of cognition. Performance appears to drop off from the second assessment to the third assessment of cognition. Chang and colleagues (2012) showed that following an acute bout of physical activity, the strongest positive effects on cognition are found within 11-20 minutes. The third assessment of cognition started about 20-25 minutes and ended about 32-37 minutes after physical activity ceased. Therefore, the third assessment of cognition may have fallen out of the time window to detect an effect of physical activity on cognition. If a positive effect was found on the third assessment of cognition, this would have given insight on the effect of an acute bout of physical activity and ostracism on cognition. Ostracism could have undermined the effect of physical activity on cognition on the third cognitive assessment compared to the inclusion condition. However, cognitive performance was not significantly different among the three experimental conditions on the third cognitive assessment. This limits the interpretation of the effects of an acute bout of physical activity and ostracism on cognition.

Another possible explanation for not finding an effect of physical activity on cognition on the third assessment of cognition is the activity used. Treadmill walking may benefit cognition only for a brief time period compared to more intense forms of physical activity such as running. Chang and colleagues (2012) showed the strongest effects occur for physical activity that is classified as “very hard.” Whether more intense forms of acute bouts of physical activity yield sustained benefits to cognition remains unclear. More research is needed to test varying intensities of acute bouts of physical activity and their relationship with cognition over time. If such a relationship is found, then more intense forms of cognition could be employed in studies measuring cognition over time.

Theoretical Implications

This thesis replicated previously documented psychological and emotional effects of ostracism (Williams, 2007a). Findings generally support Williams’ (2007a, 2007b) temporal need threat model, where targets of ostracism experience threats to primary needs (e.g. belonging, self-esteem, control, and existence), decreased positive affect, and increased negative affect. Future research may add support to Williams’ temporal need threat model by measuring how much social pain a participant experiences. Social pain was not explicitly measured in the present study. Eisenberger and colleagues (2003) used neuroimaging to capture activation of a brain structure correlated with physical pain. These measurements may be impractical given that few researchers have access to neuroimaging techniques. Therefore, future research may benefit by administering questionnaires that can accurately assess how much social pain a participant experiences. Given that the cognitive deconstruction hypothesis has received empirical support, future research explicitly addressing the role of social pain in the temporal need threat model may improve understanding of the effects of ostracism (Baumeister et al., 2002; Eisenberger & Lieberman, 2004).

This is the only known research endeavor that introduced physical activity as a strategy to counteract the effects of ostracism. This study found that ostracism following an acute bout of physical activity influenced participants' needs threat and mood compared to rest. These findings suggest possible unintended consequences of being physically active before an event of ostracism. An acute bout of physical activity may make targets more attentive to social information, thereby making an ostracism event more salient. An interesting question is if physical activity can facilitate the regulation of the psychological and emotional effects of ostracism after ostracism occurs. If someone is ostracized, would walking or running help recovery from the psychological and emotional effects of ostracism faster than a sedentary activity? This question would call for a different design than the one used in the current study, where participants are ostracized first and then given an acute bout of physical activity as a strategy to reduce the effects of ostracism or speed up recovery. This may be a more practical solution than exercising before an event of ostracism because ostracism typically occurs in an unpredictable fashion without explanation or attention (Williams, 2007a). However, more research is needed to specifically address the effect of physical activity on the psychological and emotional effects of ostracism. This line of research is promising given that physical activity and exercise have been widely studied as successful strategies to improve mood and reduce anxiety (Petruzzello, 2012). Short bouts of walking were identified to induce significant affective changes towards emotions of positive valence (Ekkekakis & Petruzzello, 1999).

Another unique contribution of this thesis to the ostracism literature is to show that ostracism does not affect executive functioning. Research investigating the cognitive effects of ostracism is still in its infancy. We found that ostracism appears to not impair inhibitory control or performance monitoring. When examining the rest and exclusion condition, there were no detrimental effects to inhibitory control or performance monitoring. This null effect neither supports the Social Monitoring System nor the cognitive deconstruction hypothesis (Baumeister et al., 2002; Pickett & Gardner, 2005). The Social Monitoring System posits that social exclusion results in a heightened awareness of social information whereas the cognitive deconstruction hypothesis maintains that monitoring is compromised following social exclusion.

Previous research has found that inhibitory control and monitoring may be adversely affected following ostracism (Ball, 2011). Future research may benefit from exploring other components of executive functioning such as working memory and cognitive flexibility as multiple components of executive functioning could be compromised following an event of ostracism. This holistic approach would help direct future ostracism and cognition research by showing which components of executive functioning, if any, are most sensitive to ostracism and warrant the most attention. Research investigating the cognitive effects of ostracism is scarce; therefore efforts to investigate multiple components of executive functioning are likely to benefit our understanding of ostracism. If executive functioning is disrupted following an event of ostracism, this finding would enhance Williams' (2007a) temporal need threat model and further support Baumeister and colleagues' (2005) cognitive deconstruction hypothesis.

Limitations and Future Directions

This study addressed the effect of exercise on executive functioning and the effect of exercise and ostracism on executive functioning. Failure to find significant effects for the effect of exercise and ostracism on cognition may be due to several factors. Previous research indicates that most targets of ostracism using the Cyberball paradigm recover in a few seconds to minutes (Williams, 2009). One limitation is that participants could have recovered from the effects of Cyberball before the third cognitive assessment. However, this is unlikely given that previous research has found significant effects of ostracism on monitoring during the same time window as in the present study (Ball, 2011). Assessing a participant's level of needs threat and mood before the cognitive task that follows Cyberball would enhance understanding of participant recovery from the effects of ostracism. This can be accomplished by asking participants their current level of need threat and mood at multiple time points.

A further limitation is the observed practice effects on the flanker task, which may have contributed to the failure to observe ostracism effects. The exposure to cognitive task may have most likely contributed to practice effects. In Ball's (2011) study cognition was assessed only twice whereas participants in the present study were assessed 18 times. The lower number of assessments may have avoided practice effects and left room to observe an effect of ostracism on cognition. An alternative solution to having multiple assessments of cognition may be to have a practice day, which would mimic a testing day but contain no manipulations (e.g., O'Leary et al., 2011). This highlights another limitation that giving participants one practice block was insufficient to avoid practice effects. Our cognitive data showed that participants performed poorer on first testing visit compared to the second and third testing visits. After a day of testing, participants may be performing at their capacity. Participants performing at their capacity may be an ideal time to introduce manipulations to test whether an acute bout of physical activity or ostracism could have an effect.

Furthermore, the flanker task specifically measures interference control, which is an aspect of inhibitory control. The modified flanker task was adjusted from previous studies to include more trials in order to observed more errors. This resulted in a total of 600 trials which took approximately 12 minutes to complete during each cognitive assessment. Although the flanker task includes trials where interference control is required (i.e., incongruent trials), by combining both the mostly congruent and mostly incongruent blocks, the adjustments to the modified flanker task may not reflect executive functioning per se but most likely sustained attention. Future research may benefit from making fewer adjustments to the modified flanker task or use other inhibitory control measures that reflect behavioral inhibition (e.g., Go-NoGo).

Another limitation, related to the practice effects on the flanker task, is the order in which participants progressed through the study. The order significantly influenced cognitive performance, Needs Threat Scale scores, and mood scores. Most previous research utilizes between-subject designs to assess differences between the inclusion and exclusion conditions of Cyberball (Williams, 2007a; 2007b). Although the Cyberball manipulation check was uninfluenced by the order in which participants progressed through the study, executive functioning, needs threat, and mood were. It is possible that Cyberball in repeated measures designs may offer diminishing psychological effects the more often participants become excluded, even when the exclusion is objectively evident to participants. There is a difficult balance that must be obtained when attempting to study exercise and ostracism together. Physical activity and cognition studies that use within-subject designs generally show benefits to cognition, while studies investigating the effects of ostracism use between-subject designs (Ball, 2011; Chang et al., 2012; Chester et al., 2013). Future work may benefit from using a mixed design with manipulations (e.g., physical activity and ostracism) as between-subject factors and cognitive assessment as a within-subject factor.

A delimitation of the current study is that we chose to include only three experimental conditions (e.g., rest and exclusion, exercise and inclusion, and exercise and exclusion). This was decided because including a fifth visit to the lab would have significantly increased the time investment for the participant which could contribute to participant attrition and the overall time required to collect data. Adding an additional testing visit to the study would have increased data collection by approximately 60 hours. The current study required approximately 220 hours of data collection. However, one limitation is that the study is missing a fourth condition (rest and inclusion). This condition would have served as a control condition as a basis to interpret the effects of the other three experimental conditions. Despite this limitation, this design allowed for the testing of the effect of exercise on cognition and the effect of exercise and ostracism on cognition. Future research may benefit from using between-subject design which would allow for all four experimental conditions and reduce the time investment for participants.

Conclusion

Interventions designed to counteract the effects of ostracism have rarely been examined in experimental research. The current study used an acute bout of physical activity, shown to enhance executive functioning, as a strategy to counteract cognitive disruptions of ostracism. Despite finding evidence for the reflexive effects of ostracism (e.g., threatened primary needs and mood) and exercise on executive functioning, an effect of ostracism on executive functioning was not observed. It remains unclear if and precisely how ostracism affects executive functioning in college-aged young adults.

Although there were several shortcomings of this project, there are numerous directions for future research. One area worth exploring is how exercise may increase attention towards social information. This may have been illustrated by participants feeling more ignored in the exercise and exclusion condition than the rest and exclusion condition. Another area for future research is to examine the effect of ostracism on other components of executive functioning. Ostracism may not disrupt inhibitory control, but working memory or cognitive flexibility may be sensitive to the effects of ostracism. The present study was inconclusive on cognitive effects of ostracism following an acute bout of physical activity. However, testing the effects of an acute bout of physical activity following ostracism may be a more promising research endeavor. Physical activity may be useful in treating the cognitive, emotional, and psychological effects of ostracism after ostracism occurs. Researchers should consider addressing these future directions because there remains a need to explore strategies to reduce the effects of ostracism, especially those using physical activity.

APPENDICES

APPENDIX A

Demographic and Health History Questionnaire

Demographics Questionnaire and Health History Questionnaire

Please answer the following questions to the best of your ability.

General Information

1. What is your date of birth? _________/_________/_________
2. What is your current age? __________years
3. How many years of education have you completed? ____________________
   (High School = 12; College = 16)
4. What is your sex? □ Male □ Female
5. What is your race?
   - □ American Indian or Alaska Native
   - □ Asian
   - □ Black or African American
   - □ Native Hawaiian or Other Pacific Islander
   - □ White
   - □ Mixed (list groups):____
   - □ Other (write in):____
6. Which is your dominant hand? □ Right □ Left □No Preference

General Health Information

1. Do you wear contacts or glasses? □ Yes □ No
   If yes, what is your prescription for?
2. Have you ever been diagnosed with an attentional disorder? □ Yes □ No
3. Have you ever been diagnosed with asthma? □ Yes □ No
4. Are you epileptic? □ Yes □ No
5. Have you experienced or been hospitalized in the last six months for traumatic brain injury, concussion with loss of consciousness, or neurological health issues?
   □ Yes □ No

APPENDIX B

Physical Activity Readiness Questionnaire

Physical Activity Readiness Questionnaire

Physical Activity Readiness Questionnaire			
Do you have any of the following:			
1.	□ Yes	□ No	Pain or discomfort in the chest, neck, jaw, arms, or other areas that may be related to poor circulation.
2.	□ Yes	□ No	Heartbeats or palpitations that feel more frequent or forceful than usual or feeling that your heart is beating very rapidly.
3.	□ Yes	□ No	Unusual dizziness or fainting.
4.	□ Yes	□ No	Shortness of breath while lying flat or a sudden difficulty in breathing that wakes you up while sleeping.
5.	□ Yes	□ No	Shortness of breath at rest or with mild exertion (such as walking two blocks).
6.	□ Yes	□ No	Feeling lame or pain in the legs brought on by walking.

APPENDIX C

Leisure-Time Exercise Questionnaire

Leisure-Time Exercise Questionnaire

1. During a typical **7-Day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your free time. For example one hour = 4, 15-minute intervals. Write on each line the appropriate number of 15 minute intervals.

Times Per Week

a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY) (e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)	____________
b) MODERATE EXERCISE (NOT EXHAUSTING) (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)	____________
c) MILD EXERCISE (MINIMAL EFFORT) (e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)	____________

APPENDIX D

Social Phobia and Anxiety Inventory

Social Phobia and Anxiety Inventory

Please use the scale listed below and circle the number which best reflects how frequently you experience these responses.

INSTRUCTIONS: On the next page is a list of behaviors that may or may not be relevant for you. Based on your personal experience, please indicate how frequently you experience these feelings and thoughts in social situations. A social situation is a gathering of two or more people (e.g., a meeting; a lecture; a party; bar or restaurant; conversing with one other person or group of people). *Feeling anxious is a measure of how tense, nervous, or uncomfortable you are during social encounters.*

	Never	Very Infrequent	Infrequent	Sometimes	Frequent	Very Frequent	Always
1. I feel anxious when entering social situations where there is a small group	0	1	2	3	4	5	6
2. I feel anxious when entering social situations where there is a large group	0	1	2	3	4	5	6
3. I feel anxious when I am in a social situation and I become the center of attention	0	1	2	3	4	5	6
4. I feel anxious when I am in a social situation and I am expected to engage in some activity	0	1	2	3	4	5	6
5. I feel anxious when making a speech in front of an audience	0	1	2	3	4	5	6
6. I feel anxious when speaking in a small informal meeting	0	1	2	3	4	5	6
7. I feel so anxious about attending social gatherings that I avoid these situations	0	1	2	3	4	5	6
8. I feel so anxious in social situations that I leave the social gathering	0	1	2	3	4	5	6
9. I feel anxious when in a small gathering with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
10. I feel anxious when in a large gathering with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6

opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
11. I feel anxious when in a bar or restaurant with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
12. I feel anxious and I do not know what to do when in a new situation with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
13. I feel anxious and I do not know what to do when in a situation involving confrontation with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
14. I feel anxious and I do not know what to do when in an embarrassing situation with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
15. I feel anxious when discussing intimate feelings with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
16. I feel anxious when stating an opinion to:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
17. I feel anxious when talking about business with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
18. I feel anxious when approaching and/or initiating a conversation with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6

19. I feel anxious when having to interact for longer than a few minutes with:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
20. I feel anxious when drinking (any type of beverage) and/or eating in front of:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
21. I feel anxious when writing or typing in front of:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
22. I feel anxious when speaking in front of:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
23. I feel anxious when being criticized or rejected by:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
24. I attempt to avoid social situations where there are:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6
25. I leave social situations where there are:							
strangers	0	1	2	3	4	5	6
authority figures	0	1	2	3	4	5	6
opposite sex	0	1	2	3	4	5	6
people in general	0	1	2	3	4	5	6

26. Before entering a social situation I think about all the things that can go wrong. The types of thoughts I experience are:							
Will I be dressed properly?	0	1	2	3	4	5	6
I will probably make a mistake and look foolish	0	1	2	3	4	5	6
What will I do if no one speaks to me?	0	1	2	3	4	5	6
If there is a lag in the conversation, what can I talk about?	0	1	2	3	4	5	6
People will notice how anxious I am	0	1	2	3	4	5	6
27. I feel anxious before entering a social situation	0	1	2	3	4	5	6
28. My voice leaves me or changes when I am talking in a social situation	0	1	2	3	4	5	6
29. I am not likely to speak to people until they speak to me	0	1	2	3	4	5	6
30. I experience troubling thoughts when I am in a social setting. For example:							
I wish I could leave and avoid the whole situation	0	1	2	3	4	5	6
If I mess up again I will really lose my confidence	0	1	2	3	4	5	6
What kind of impression am I making?	0	1	2	3	4	5	6
Whatever I say it will probably sound stupid	0	1	2	3	4	5	6
31. I experience the following prior to entering a social situation:							
Sweating	0	1	2	3	4	5	6
Frequent urge to urinate	0	1	2	3	4	5	6
Heart palpitations	0	1	2	3	4	5	6
32. I experience the following in a social situation:							
Sweating	0	1	2	3	4	5	6
Blushing	0	1	2	3	4	5	6
Shaking	0	1	2	3	4	5	6
Frequent urge to urinate	0	1	2	3	4	5	6
Heart palpitations	0	1	2	3	4	5	6
33. I feel anxious when I am home alone	0	1	2	3	4	5	6
34. I feel anxious when I am in a strange place	0	1	2	3	4	5	6

35. I feel anxious when I am on any form of public transportation (e.g.,, bus, train, airplane)	0	1	2	3	4	5	6
36. I feel anxious when crossing streets	0	1	2	3	4	5	6
37. I feel anxious when I am in crowded public places (e.g.,, stores, church, movies, restaurants, etc.)	0	1	2	3	4	5	6
38. Being in large open spaces makes me feel anxious	0	1	2	3	4	5	6
39. I feel anxious when I am enclosed in places (e.g.,, elevators, tunnels, etc.)	0	1	2	3	4	5	6
40. Being in high places makes me feel anxious (e.g.,, tall buildings)	0	1	2	3	4	5	6
41. I feel anxious when waiting in a long line	0	1	2	3	4	5	6
42. There are times when I feel like I have to hold on to things because I am afraid I will fall	0	1	2	3	4	5	6
43. When I leave home and go to various places, I go with a family member or a friend	0	1	2	3	4	5	6
44. I feel anxious when riding in a car	0	1	2	3	4	5	6
45. There are certain places I do not go to because I may feel trapped	0	1	2	3	4	5	6

APPENDIX E

Needs Threat and Mood Questionnaires

Needs Threat Scale and Mood Questionnaire

For each question, please circle the number to the right that best represents the feelings you were experiencing during the game.

Question	**Not at all**				**Extremely**
Belonging					
I felt "disconnected" (R)	1	2	3	4	5
I felt rejected (R)	1	2	3	4	5
I felt like an outsider (R)	1	2	3	4	5
I felt I belonged to the group	1	2	3	4	5
I felt the other players interacted with me a lot	1	2	3	4	5
Self-esteem					
I felt good about myself	1	2	3	4	5
My self-esteem was high	1	2	3	4	5
I felt liked	1	2	3	4	5
I felt insecure (R)	1	2	3	4	5
I felt satisfied	1	2	3	4	5
Meaningful Existence					
I felt invisible (R)	1	2	3	4	5
I felt meaningless (R)	1	2	3	4	5
I felt nonexistent (R)	1	2	3	4	5
I felt important	1	2	3	4	5
I felt useful	1	2	3	4	5
Control					
I felt powerful	1	2	3	4	5
I felt I had control over the course of the game	1	2	3	4	5
I felt I had the ability to significantly alter events	1	2	3	4	5
I felt I was unable to influence the action of others (R)	1	2	3	4	5
I felt the other players decided everything (R)	1	2	3	4	5
Mood					
Good	1	2	3	4	5
Bad	1	2	3	4	5
Friendly	1	2	3	4	5
Angry	1	2	3	4	5
Pleasant	1	2	3	4	5
Happy	1	2	3	4	5
Sad	1	2	3	4	5

** Note items are blocked to show subscales. Items were randomly intermixed for each questionnaire before administering to participants. (R) indicates item was reverse scored.*

APPENDIX F

Ostracism Manipulation Check

Ostracism Manipulation Check

For the next three questions, please circle the number to the right (or fill in the blank) that best represents the thoughts you had during the game

Question	**Not at all**			**Extremely**	
I was ignored	1	2	3	4	5
I was excluded	1	2	3	4	5
Assuming the ball should be thrown to each person equally (33% if three people), what percentage of throws did you receive?	___ %				

APPENDIX G

Contact E-Mail to Students

Contact E-Mail to Students

Subject: KIN173 Research Opportunity

As a student in KIN173: Foundations of Kinesiology you are invited to participate in a research project. The purpose of this research is to examine the relationship between physical activity (walking for 20 minutes) and computer task performance. Involvement in this study would require coming to our lab on four separate occasions, the first for approximately 30 minutes, the next two for about 75 minutes, and the last for about 90 minutes. In the sessions you will be asked to complete surveys and computer tasks and to walk on a treadmill (two of the visits). We will ask that you not be physically active/exercise or consume large amounts of caffeine prior to coming to the lab on your scheduled days.

Testing will be conducted in IM Sports Circle (308 W. Circle Drive; East Lansing, MI 48824). You should wear appropriate clothing for light exercise that will allow you to move freely and wear a standard heart rate monitor. If you participate and complete all sessions you will be given 10 points of extra credit in KIN173: Foundations of Kinesiology.

If you are interested in participating in this research, please contact me at the email or phone number below.

As always, we appreciate your interest in our research and your consideration of this study.

Sincerely,

Anthony Delli Paoli
dellipao@msu.edu
517-353-6497

APPENDIX H

Purpose Script Read to Participants

Purpose Script Read to Participants

Evidence suggests that physical activity has potential to affect certain aspects of cognition. Therefore, we would like to test whether treadmill walking will affect computer task performance. We want to learn if physical activity and attention are linked. On each visit to the lab, we will assess your computer task performance once before you are physically active or sedentary and twice after you are physically active or sedentary. To pass the time in between administrations of the computer task you will watch a video when on the treadmill or seated and you will practice visualizing the act of throwing a ball.

APPENDIX I

Participation Information and Consent Form

Participation Information and Consent Form

Participant Information and Consent Form
"Physical Activity and Computer Task Performance**"**

Investigator Directing Research: Alan L. Smith, Ph.D., Professor and chairperson, Department of Kinesiology, Michigan State University, 134 IM Sports Circle, East Lansing, MI 48824-1049, alsmith@msu.edu or 517-355-4731

We invite you to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have.

Purpose of the Research: Evidence suggests that physical activity has potential to affect certain aspects of cognition. Therefore, we would like to test whether treadmill walking will affect computer task performance. We want to learn if physical activity and attention are linked.

What You Will Do: If you agree to participate, you will come to the lab on four separate days (including today). You will not participate in exercise or drink caffeinated beverages on these days. On the first day you will be asked to fill out this form, complete a questionnaire packet, and have your height and weight recorded. You will then be scheduled for the next three visits. While you are in the lab on these days, you will be asked to complete cognitive tests and questionnaires, which should take approximately 75-90 minutes to complete:

- **Questionnaires–** After completing this informed consent, you will be asked to complete a series of paper and pencil based questionnaires. This should take about 20 minutes today. On your final visit to the laboratory we will have you complete additional questions after computer tasks are completed.

- **Experimental Conditions –** On visits 2, 3, and 4 you will either watch a video at a desk or exercise while watching a video for 20 minutes. On the day that you exercise, you will be given an orientation to the treadmill and a brief warm up. Then you will be asked to walk at a level similar to walking to class. At the start of each session we will ask you to wear a heart rate monitor so we can measure how hard your heart is working.

- **Cognitive Tasks** – During each visit you will be asked to complete two computer-based tasks. One of these tasks will be presented three times during your visit to allow us to look at different aspects of attention. Each administration takes about 12 minutes. The other task, which is presented once during your visit, takes about 4 minutes and involves visualization of ball throwing.

Privacy and Confidentiality: Any responses and information you provide are kept confidential. All data we collect will be numerically coded and grouped with data from other participants. Once the study is complete and we destroy our list matching your name with your ID number, there will be no way to connect you to your data. All records will be kept for a minimum of 3 years in a locked secure location and your confidentiality will be protected to the maximum extent of the law. However, when required by law, government representatives and the Michigan State University Institutional Review Board may deem it necessary to look at and/or copy your information. All data obtained from this study will be used for research purposes only, not for the evaluation or diagnosis of any disorder.

Your Rights to Participate, Say No, or Withdraw: Participation in this project is entirely voluntary. You are free to withdraw your participation should you, at any time, find any of these procedures uncomfortable. You may choose to skip a question at any time if you feel uncomfortable and do not wish to answer it. You may also choose to discontinue your participation in the study without penalty. Your decisions will not impact your relationship with your course instructor. Inform the research staff if you are thinking about stopping or deciding to stop, so that they can tell you how to do so safely.

Costs and Compensation for Participation: Participation in this research study is free, though any costs associated with parking on campus will be your responsibility. If you complete the four study visits, you will receive up to 2.5% extra credit points added to your final grade. If you decide to withdraw early from the experiment, you will receive credit depending on the number of lab visits: one visit = 0.25% points, two visits = 0.75% points, three visits = 1.25% points.

Alternative Options: If you do not wish to participate in this study, there are other ways to earn up to 10 extra credit points in your class. You may choose to write up to two 1-page papers (600 words minimum of writing) on one of the lecture topics. In each paper use at least 2 peer-reviewed journal articles not assigned as part of the course reading, and include APA style in-text citations and references. Each paper will be worth up to 1.25% extra credit points.

Potential Benefits: If you agree to take part in this study, there may not be any direct benefit to you. We hope to gain further insight into the relationship between physical activity and cognition. Such insight may benefit scientific progress and inform us how to make best use of physical activity to benefit health and well-being.

Potential Risks: All procedures, techniques, equipment, and measures used in this study are routinely used in educational and research settings. No methods are used that are new, untested, or of questionable safety. You may experience some minor skin irritation from the application of the heart rate monitor. Also, when individuals who have been sedentary engage in even light exercise, there is a chance of incurring minor injury and some discomfort from using major muscle groups that have not been used much recently. Major injury is rare. If you become injured, we encourage you to notify the research staff and to consult your physician if necessary. Though extremely rare, sudden death or cardiac irregularities can occur while exercising. We minimize these risks through screening and inclusion/exclusion criteria. To further mitigate risk, we provide safety instructions while orienting you to equipment and at least one researcher working with you is trained in Cardiopulmonary Resuscitation (CPR). Finally, some participants will be uncomfortable with the computer tasks or particular survey questions. You are not required to complete tasks or items that make you uncomfortable, though you must complete our initial safety/screening questions to be involved in the study. Skipping tasks or items during a lab visit does not affect the extra credit points that you will earn.

Your Rights to Get Help if Injured: If you are injured as a result of your participation in this research project, Michigan State University will assist you in obtaining emergency care, if necessary, for your research-related injuries. If you have insurance for medical care, your insurance carrier will be billed in the ordinary manner. Any costs that are not covered or in excess of what are paid by your insurance, including deductibles, will be your responsibility. The University's policy is not to provide financial compensation for lost wages, disability, pain or discomfort, unless required by law to do so. This does not mean that you are giving up any legal rights you may have. If at any time, day or night, you experience adverse physical symptoms, you should immediately contact your personal physician or emergency personnel (i.e., dial 911).

Contact Information: If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher, Dr. Alan L. Smith, Department of Kinesiology, Michigan State University, 134 IM Sports Circle, East Lansing, MI 48824. Dr. Smith can be reached at alsmith@msu.edu or 517-355-4731.

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail: irb@msu.edu or regular mail at Olds Hall, 408 West Circle Drive #207, MSU, East Lansing, MI 48824.

Documentation of Informed Consent: Before you agree to participate, please ensure that you:

- Are aware of what you will be asked to do.
- Give your consent voluntarily.
- Know that you can withdraw your consent at any time.

Your signature below means that you voluntarily agree to participate in this research study.

Signature: ____Date: ______________________

Name: ____
Please Print

Thank you for your consideration. You will be given a copy of this form to keep.

APPENDIX J

Counterbalancing Sheet

Table 4. *Counterbalancing Sheet*

ID	Condition Order	Congruency Order	Compatibility Order	Video Order
AX01	RX	MI/MC	A	1
	EI	MI/MC	B	2
	EX	MI/MC	C	3
AX02	EI	MC/MI	A	1
	EX	MC/MI	B	2
	RX	MC/MI	C	3
AX03	EX	MI/MC	A	1
	RX	MI/MC	B	2
	EI	MI/MC	C	3
AX04	RX	MC/MI	A	1
	EI	MC/MI	B	2
	EX	MC/MI	C	3
AX44	EI	MI/MC	C	3
	EX	MI/MC	A	1
	RX	MI/MC	B	2
AX45	EX	MC/MI	C	3
	RX	MC/MI	A	1
	EI	MC/MI	B	2
AX46	RX	MI/MC	C	3
	EI	MI/MC	A	1
	EX	MI/MC	B	2
AX47	EI	MC/MI	C	3
	EX	MC/MI	A	1
	RX	MC/MI	B	2
AX48	EX	MI/MC	C	3
	RX	MI/MC	A	1
	EI	MI/MC	B	2

Note: Table includes example data for demonstration purposes. Counterbalancing contained 3 condition orders (RX, EI, EX; EI, EX, RX; or EX, RX, EI), 2 compatibility orders (MC/MI, MI/MC), 3 flanker orders (ABC, BCA, CAB), and 3 video orders (123, 231, 312). Every participant received one of two compatibility orders (e.g., MI or MC) consistently as the first block for all flanker task assessments throughout the study. Dashed line represents a break to demonstrate the first four and last five counterbalanced orders.

APPENDIX K

Run Sheet and Heart Rate Record

Run Sheet and Heart Rate Record

Paperwork		
Informed Consent_____	Day 1 Packet______	Checklist______
Date: ___/___/___	Day: □1 □2 □3	Start Time___:___ AM PM
Options		
Condition: □ RX □ EI □ EX	First Block: □ C □ I	Flanker: □ A □ B □ C
Video #: □ 1 □ 2 □ 3		
Practice Cognitive Task		
Filename: _________(**AX**##EX**1P**)		Stopwatch Time: ___:___:___
* Remember letters that are not bolded are to be replaced with the indicated information in the Options section of this sheet. See the Computer Task Naming Breakdown Sheet for more info		Check Accuracy: _______%
Cognitive Task 1 Block 1		
Filename: __________(**AX**##EX**1**C)		Stopwatch Time: ___:___:___
		Check Accuracy: _______%
Cognitive Task 1 Block 2		
Filename: __________(**AX**##EX**1**C)		Stopwatch Time: ___:___:___
		Check Accuracy: _______%
Cognitive Task 2 Block 1		
Filename: __________(**AX**##EX**2**C)		Stopwatch Time: ___:___:___
		Check Accuracy: _______%
Cognitive Task 2 Block 2		
Filename: __________(**AX**##EX**2**C)		Stopwatch Time: ___:___:___
		Check Accuracy: _______%

Cognitive Task 3
Block 1

Filename: __________(**AX**##EX**3**C)

Stopwatch Time: ___:___:___

Check Accuracy: _______%

Cognitive Task 3
Block 2

Filename: __________(**AX**##EX**3**C)

Stopwatch Time: ___:___:___

Check Accuracy: _______%

Heart Rate

HRmax:___________bpm

HRmax = (220 – age)

Baseline HR: _______bpm

60% HRmax: _______bpm

60% HRmax = 0.6 * HRmax

10% Baseline Range:_____ to ______

Index	Activity	Time	HR (bpm)	Index	Activity	Time	HR (bpm)
1	Baseline	00:00:00		36		01:10:00	
2		00:02:00		37		01:12:00	
3		00:04:00		38		01:14:00	
4		00:06:00		39		01:16:00	
5		00:08:00		40		01:18:00	
6		00:10:00		41		01:20:00	
7		00:12:00		42		01:22:00	
8		00:14:00		43		01:24:00	
9		00:16:00		44		01:26:00	
10		00:18:00		45		01:28:00	
11		00:20:00		46		01:30:00	
12		00:22:00		47		01:32:00	
13		00:24:00		48		01:34:00	
14		00:26:00		49		01:36:00	
15		00:28:00		50		01:38:00	
16		00:30:00		51		01:40:00	
17		00:32:00		52		01:42:00	
18		00:34:00		53		01:44:00	
19		00:36:00		54		01:46:00	
20		00:38:00		55		01:48:00	
21		00:40:00		56		01:50:00	
22		00:42:00		57		01:52:00	
23		00:44:00		58		01:54:00	
24		00:46:00		59		01:56:00	
25		00:48:00		60		01:58:00	
26		00:50:00		61		02:00:00	
27		00:52:00		62		02:02:00	
28		00:54:00		63		02:04:00	
29		00:56:00		64		02:06:00	
30		00:58:00		65		02:08:00	
31		01:00:00		66		02:10:00	
32		01:02:00		67		02:12:00	
33		01:04:00		68		02:14:00	
34		01:06:00		69		02:16:00	
35		01:08:00		70		02:18:00	

Comments: (if an error occurs, write EXACTLY what the error message says below)

APPENDIX L

Cyberball Instructions

Cyberball Instructions

Mental Visualization Task

In a few moments, you will be playing a ball tossing game with other students over our network. The game is very simple. When the ball is tossed to you, simply click on the name of the player you want to throw it to.

What is important is not your ball tossing performance, but that you ***MENTALLY VISUALISE*** the entire experience. Imagine what the others look like. What sort of people are they? Where are you playing? Is it warm and sunny or cold and rainy? Create in your mind a complete mental picture of what might be going on if you were playing this game in real life.

Okay, ready to begin? Please click on the following link to begin: Start Playing Now

APPENDIX M

Participant Debriefing Statement and Consent Form

Participant Debriefing Statement and Consent to Use Data Form
"Physical Activity and Computer Task Performance**"**

Investigator Directing Research: Alan L. Smith, Ph.D., Professor and chairperson, Department of Kinesiology, Michigan State University, 134 IM Sports Circle, East Lansing, MI 48824-1049, alsmith@msu.edu or 517-355-4731

Purpose of the Research: Thank you for participating in this study. We provided you a general purpose for the study when you consented to participate, but had an additional specific purpose that we did not disclose at that time. This was to examine the effects of a mild form of ostracism (being excluded) on cognition following light physical activity. We are interested in your performance on the computer task that involved determining arrow direction. This task represents the ability to successfully orient attention toward the center arrow and ignore distracting information from the other arrows. We will compare this performance across the conditions, which sometimes included physical activity and/or mild ostracism. This research will help us better understand the link between social factors, cognition, and physical activity.

Specific Procedures Used: The ostracism was created by the ball throwing game. Sometimes you received a fair share (one third) of the the throws, whereas other times you received very few throws (i.e.,, were excluded). You were not actually playing the game with other people. The computer ran the game and determined how often you received the ball. The sequence of visits in which you experienced mild ostracism was randomly determined, though all participants received all experimental conditions across the visits to the lab.

Why Deception Was Necessary: Deception is necessary for this research so that the experimenters can measure reactions to inclusion and exclusion (ostracism). In order to see how people respond naturally, it was necessary not to reveal this aspect of the experiment until you completed the entire study.

Privacy and Confidentiality: Any responses and information you provided will be kept confidential. All data we collected were numerically coded and will be grouped with data from other participants. Once the study is complete and we destroy our list matching your name with your ID number, there will be no way to connect you to your data. All records will be kept for a minimum of 3 years in a locked secure location and your confidentiality will be protected to the maximum extent of the law. However, government representatives (including the FDA), when required by law, and the Michigan State University Institutional Review Board may deem it necessary to look at and/or copy your information. All data obtained from this study will be used for research purposes only, not for the evaluation or diagnosis of any disorder.

Contact Information: If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher, Dr. Alan L. Smith, Department of Kinesiology, Michigan State University, 134 IM Sports Circle, East Lansing, MI 48824. Dr. Smith can be reached at alsmith@msu.edu or 517-355-4731.

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research

Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail: irb@msu.edu or regular mail at 207 Olds Hall, MSU, East Lansing, MI 48824.

After reading this consent form you acknowledge:

- **I HAVE BEEN FULLY DEBRIEFED BY THE EXPERIMENTER.**
- **I HAVE HAD THE OPPORTUNITY TO READ THIS CONSENT FORM.**
- **I HAVE BEEN GIVEN THE OPPORTUNITY TO ASK QUESTIONS ABOUT THE RESEARCH PROJECT.**

As a result,

______ PLEASE DISCARD ALL MY DATA

______I GIVE PERMISSION TO HAVE MY DATA USED IN THIS RESEARCH PROJECT

Please initial one of the above options

Signature: ____Date: ______________________

Name: ____
Please Print

Thank you for your consideration. You will be given a copy of this form to keep.

WORKS CITED

WORKS CITED

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