

EFFECTS OF PHYSICAL ACTIVITY AND AEROBIC FITNESS ON
RESPONSES TO SOCIAL EXCLUSION

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Social exclusion is a term used to describe an array of interpersonal behaviors that signal someone is unwelcomed, does not belong, or is devalued. Being left out or ignored can emotionally wear a person down. Research shows that social exclusion does not feel good and can impair cognitive performance. Yet, little is known on what people can do to help them cope with being excluded. This dissertation examined physical activity and aerobic fitness as ways to help people cope with social exclusion.

The purpose of the first study was to understand if walking could help reduce the effects of social exclusion on the feelings and cognitive performance of participants. Female college-aged participants either walked on a treadmill at a brisk pace or remained seated at a desk for 20 minutes. After walking or being seated, half of the participants were told that no other participants in the study wanted to work with them. The other half were told to complete additional tasks while waiting. Results showed that walking helped participants feel better and dampened the association of social exclusion perceptions that hurt cognitive performance. These findings suggest that preemptive walking may be an effective way to help people cope with social exclusion.

The purpose of the second study was to understand if children respond differently to social exclusion based on how aerobically fit they are. The feelings and cognitive performance of 9-to-12-year-old girls were measured after being included and after being excluded by a computer game. At the end of the study they completed a fitness assessment on a treadmill.

Results showed girls with higher fitness reported feeling better and demonstrated better cognitive performance than girls with lower fitness. These findings suggest that more aerobically fit girls may be better able to cope with social exclusion than less aerobically fit girls.

Collectively, both studies show that physical activity and fitness help people cope with negative social relationships. The results of this dissertation add to the range of positive physical and mental health outcomes associated with physical activity behavior and fitness. This may be especially important for children as physical activity participation can help improve a child's aerobic fitness. Being physically active at school in physical education or through sports can benefit aerobic fitness as well as provide meaningful opportunities for positive social relationships with peers. This dissertation offers useful ways for people to reduce the impact of social exclusion and continued research on this topic remains important.

ABSTRACT

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Social exclusion is common in daily life and has adverse effects on healthy functioning. Because of these adverse effects, there is value in exploring behaviors and attributes that may assist in coping with exclusion. Current understanding of ways to reduce the impact of social exclusion is limited. Exploratory efforts are needed to address the transient effects of social exclusion as an attempt to improve daily functioning and reduce the progression of adverse effects on healthy functioning. These transient effects are largely characterized by reductions in pleasant affect and impairments to cognitive performance. Accordingly, this dissertation examined two complementary aspects of health to address responses to social exclusion – physical activity and aerobic fitness.

The purpose of the first study was to assess walking as a strategy to reduce the effects of social exclusion on affect and working memory performance. Healthy female college students ($N = 96$, $M_{age} = 19.2 \pm 0.8$ years) were randomly assigned to one of four experimental conditions: (a) sedentary plus neutral feedback, (b) sedentary plus exclusion feedback, (c) walking plus neutral feedback, or (d) walking plus exclusion feedback. Results showed excluded participants had a significant negative shift in affect following feedback, $p < .05$. Those who were sedentary prior to exclusion had lower affect scores following exclusion than the walking plus exclusion and the neutral feedback groups, $p < .05$. There were no direct effects of walking or social exclusion on working memory. However, perceptions of being ignored predicted smaller improvements in working memory performance for participants who were sedentary prior to

exclusion, $p < .05$. The findings suggest that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions that can undermine working memory. More broadly, this work supports continued examination of physical activity as a potential strategy for helping individuals cope with negative social experiences.

The purpose of the second study was to determine if aerobic fitness moderates affective and cognitive responses to social exclusion. Healthy adolescent girls ($N = 35$, $M_{age} = 10.4 \pm 1.2$ years) completed measures of affect and working memory performance in response to a series of computer games where they were socially included and excluded. Social exclusion significantly decreased affect, $p < .001$; however, working memory performance increased from inclusion to exclusion, $p < .001$. Moderation analyses revealed aerobic fitness was positively associated with changes in affect and working memory, p 's $< .05$. Higher levels of aerobic fitness were associated with smaller decreases in affect and larger increases in working memory performance for the more challenging of two working memory tasks used in this study. These results suggest that more aerobically fit girls may be better able to cope with social exclusion than less aerobically fit girls. This research highlights a potentially important moderator for coping with social exclusion and further research is warranted.

Collectively, both studies offer a novel and complementary approach towards addressing the effects of social exclusion. Health behaviors such as physical activity are practical because they are accessible to most people to incorporate into their daily lives with low burden and cost. Both physical activity behavior and aerobic fitness are associated with a range of positive physical and mental health outcomes, which makes them particularly attractive candidates for reducing the effects of social exclusion.

The dissertation is dedicated to my wife and best friend, Courtney. Your unconditional love, patience, and support made this project possible.

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KEY TO ABBREVIATIONS

ADHD	Attention-deficit hyperactivity disorder
BH-FDR	Benjamini and Hochberg false discovery rate
BMI	body mass index
BPM	beats per minute
CFS	Children's Feeling Scale
CLA	Children's Loneliness Scale
cm	Centimeters
EVS	Empirical Valence Scale
HR	Heart rate
ITI	Inter-trial interval
kg	Kilograms
M	Statistical mean
m	Meters
ml	Milliliters
ms	Milliseconds
OES-A	Ostracism Experience Scale for Adolescents
OMNI	Children's OMNI scale of perceived exertion
RER	Respiratory exchange ratio
SD	Standard deviation
SPPC	Self-Perception Profile for Children
VO2 max	Maximum volume of oxygen that a person can use

CHAPTER 1: GENERAL INTRODUCTION

“I used to think that the worst thing in life was to end up alone. It's not. The worst thing in life is to end up with people who make you feel alone.” – Robin Williams

The importance of social relationships stems from the universal human need to form and maintain stable, meaningful, and lasting relationships, known as the need to belong (Baumeister & Leary, 1995). The need to belong has a strong evolutionary basis and exerts a considerable impact on human functioning (Baumeister & Leary, 1995). The idea that people strive for social connections has a longstanding history in the social sciences. Freud (1949) often wrote of the need for interpersonal contact among familial sources and intimate partners. Maslow's (1943) hierarchy of needs placed love and belongingness in the middle of his conceptual needs pyramid. The central theme of Bowlby's (1969) attachment theory is the need for attachment between a mother and infant. Today, there is recognized agreement that people greatly desire acceptance and social bonds with others, frequently devote attention to the status of their relationships, and behave in ways to maintain and protect their relationships (Baumeister & Leary, 1995; Leary, 2001). However, social life is dynamic and adverse social exchanges are common.

Over the past few decades, research has flourished on the effects of adverse social events and relationships, with a key example being social exclusion (Baumeister, Brewer, Tice, & Twenge, 2007; Smart Richman & Leary, 2009; Williams, 2007). Social exclusion is a process where a person is put into a condition of being alone or is denied social contact (Blackhart, Nelson, Knowles, & Baumeister, 2009). Social exclusion is associated with a range of harmful effects on psychological, physical, and interpersonal functioning (Baumeister, DeWall, Ciarocco, & Twenge, 2005; Cacioppo & Hawkley, 2009; Hawkley, Thisted, & Cacioppo, 2009; Twenge, Baumeister, DeWall, Ciarocco, & Bartels, 2007). Despite considerable understanding of these

effects, less is understood on how to temper the impact of social exclusion. Identifying what behaviors and individual characteristics may be best suited to mitigate the effects of social exclusion will benefit the knowledge base and enable the maintenance and promotion of healthy functioning.

There are four goals of this introductory chapter. The first is to provide a conceptual understanding of social exclusion. The second is to review the sequence of events following social exclusion. The third is to communicate the need to understand the effects of social exclusion during development. The final goal is to justify the need for studying factors that hold potential to temper the effects of social exclusion.

Conceptualizing Social Exclusion

Social exclusion encompasses a broad spectrum of interpersonal behaviors. Research has focused on specific manifestations or forms of social exclusion such as abandonment, loneliness, neglect, ostracism, rejection and victimization (Baumeister, Brewer, Tice, & Twenge, 2007; Espelage & Swearer, 2003; Hawker & Boulton, 2000; Leary, 2001; Reijntjes, Kamphuis, Prinzie, & Belch, 2010; Williams, 2009). Researchers have predominantly used these terms interchangeably and often juxtapose social exclusion (i.e., rejection) with inclusion (i.e., acceptance). This contrast makes understanding degrees of exclusion difficult. People may exclude some individuals more so and in different ways than others, rather than simply including or excluding them. Further, individuals may experience events of social exclusion differently, leading to discrepancies in how social exclusion is perceived. A focus on the common features among forms of social exclusion offers a solution that reduces complexity and enhances conceptual understanding.

At the core of each exclusionary experience is a threat to the need to belong (Baumeister & Leary, 1995). Objective accounts for this threat manifest in degrees of exclusion that can vary from overt (i.e., maximal exclusion) to subtle (i.e., passive exclusion) (Leary, 2001; 1990). Maximal exclusion is when others overtly reject, ostracize, abandon, or banish another person. A school-aged child being told by a group of peers she can't play with them is an example of maximal exclusion. Other forms include socially excluding an individual but to a lesser extent such that excluders do not go too far out of their way to do so (Leary, 2001). Active exclusion represents others avoiding another person but tolerating the presence of the person if and when necessary. Waiting to be selected on a team for a school-yard game, text messages going unanswered in an ongoing conversation or not being invited to a friend's party are familiar examples of active exclusion. Passive exclusion represents ignoring the individual but not to the extent of physically avoiding or rejecting. The most common example of passive exclusion is when people ignore each other in public (e.g., bus stop, elevator, park bench). Ambivalence represents others not caring whether a person is included or excluded (Leary, 1990).

These objective accounts of social exclusion are useful to understand degrees of social exclusion beyond the dichotomy of inclusion and exclusion. Despite these objective representations, people respond in a variety of ways to similar forms of social exclusion. Two people can experience an identical exclusionary event but have remarkably different reactions. For instance, some individuals may be quite distressed from being ignored by a co-worker, whereas others may think nothing of it. These disparate outcomes reveal the subjective importance of exclusionary events. That is, how people interpret and perceive interactions with others is a salient aspect of social exclusion.

Although Baumeister and Leary (1995) contend that all people maintain a desire to be socially included by others, people possess a set of standards for how they evaluate their relationships with others. These evaluations can vary across individuals (e.g., dispositions, beliefs) as well as within individuals depending on contextual factors (e.g., work, home, school) and the relation of an excluder to the individual (e.g., coach, family member, peer, teacher, stranger). The effects of social exclusion are largely a function of how individuals regard their relationships with others as valuable and important (Leary, 2001; Smart Richman & Leary, 2009). Thus, social exclusion and its many forms can be operationalized into perceived relational value. Perceived relational value is the degree to which individuals believe that others value having relationships with them (Smart Richman & Leary, 2009).

Perceived relational value is a core component of all forms of social exclusion and provides an overarching conceptual framework (Leary, 1991). The experience of social exclusion has three characteristics: (a) the individual values the relationship with another person/group, (b) the individual perceives that the other person/group should value their existing relationship prior to social exclusion, and (c) experiencing or anticipating a potential event of social exclusion is perceived to damage the existing relationship such that individual perceives the other person/group values the relationship less or devalues the relationship. A decreased perceived evaluation or a perceived devaluation may trigger social exclusion effects. Individuals range in these perceptions and therefore can have varying responses to social exclusion.

A Theoretical Framework of Social Exclusion

There are a number of hypotheses that detail the effects of social exclusion and its many forms. The primary goal of these hypotheses is to account for the array of behavioral, emotional, and psychological effects documented through experimental, cross-sectional, and longitudinal research. Currently, there is no overarching theory that accounts for the entire array of effects of social exclusion. Early approaches to studying social exclusion relied on cross-sectional or longitudinal research (e.g., Asher, Hymel, & Renshaw, 1984; Asher & Wheeler, 1985; Newcomb et al., 1993). These approaches highlighted the range of maladaptive outcomes for individuals who are frequently socially excluded but were unable to directly test the process of how social exclusion may develop into maladaptive outcomes. Over the past two decades, a growing body of laboratory research has focused on the direct effects of social exclusion. This research has revealed the process of being excluded and how social exclusion immediately impacts the thoughts, feelings, and behaviors of people.

A theory that focuses on the immediate effects of social exclusion is Williams's (2007; 2009) temporal need threat model. The theory is useful for understanding the effects of social exclusion despite being primarily developed as a theory specific to ostracism. Ostracism is the process of ignoring and socially excluding individuals or groups by other individuals or groups (Williams, 2007). This model posits the effects of social exclusion follow a progressive sequence. The first stage to occur is *reflexive* (i.e., immediate) and includes effects characterized by a diminished sense of belonging, self-esteem, control, and meaningful existence psychological needs and reduced pleasant affect. The reflexive stage is then followed by a *reflective* stage characterized by cognitive appraisals of the social situation to assess what happened and how to respond accordingly. During the reflective stage excluded individuals

engage in self-regulation strategies to cope, reduce the effects of the reflexive stage, and manage emotion (Williams, 2007; Williams & Nida, 2011). The need threat model acknowledges long-term effects of social exclusion when an individual's ability to cope becomes less effective because of chronic exposure to exclusion (i.e., solitary confinement, consistent neglect and loneliness among peers). This long-term effect is labeled the *resignation stage*. This stage has received little attention because of the logistical and ethical challenges with chronically excluding individuals in an experimental setting. Therefore, the need threat model is commonly used in research targeting the immediate effects of social exclusion.

Reflexive Stage

A hallmark effect of the reflexive stage is how people feel after being excluded. Multiple theoretical perspectives inform how people experience, express, and respond to different feelings. One perspective conceptualizes emotions as distinct states (Lazarus, 1982). All affective states maintain some unique appraisals, expressions, and behaviors relative to others, which make them distinct from each other (Izard, 1993). This approach may be useful if a researcher is interested in, for example, the role of anger in the moments after social exclusion and the effect of anger on aggression (e.g., Leary, Twenge, & Quinlivan, 2006). A second perspective uses a constructionist approach to understand affect and emotion. Emotions are complex mental states arising from primitive, conscious, irreducible raw feelings termed core affect (Barret, 2011; Barrett, Mesquita, Ochsner, & Gross, 2007; Russel, 2003). Core affect is unreflective in that it is not attributed to any object, belief, or perception. Core affect contains valence and arousal dimensions with affective valence ranging along a continuum from pleasant to unpleasant and arousal ranging along a continuum of high to low. Pleasant valence signals helpful or rewarding events and unpleasant valence signals harmful or threatening events

(Panksepp, 1998; 2005). Emotions arise when core affect is attributed to a specific object or event in time (Russel, 2003). Thus, emotions require some situational and relational content. Given the evolutionary links between the functional role of affect and social relationships, the typical affective response to social exclusion is characterized by unpleasant affect to signal attention to a perceived environmental threat (see MacDonald & Leary, 2005).

Researchers originally hypothesized that social exclusion would be quite distressful and upsetting because the need to belong is deep-rooted within the human psyche (Twenge, Baumeister, Tice, & Stucke, 2001; Twenge, Catanese, & Baumeister, 2003). The contemporary view is that people typically respond to social exclusion with “hurt feelings” (MacDonald & Leary, 2005). However, current understanding of “hurt feelings” as an affective response is debated among social exclusion researchers (Baumeister, DeWall, & Vohs, 2009; Blackhart et al., 2009; Gerber & Wheeler, 2009). A collective body of evidence shows that social exclusion can increase negative affect (Gerber & Wheeler, 2009), induce social pain (MacDonald & Leary, 2005), make people emotionally numb (DeWall & Baumeister, 2006), or simply wipe away all pleasant feelings (Blackhart et al., 2009).

The variability among research findings may be due to differences among social exclusion paradigms in laboratory research, affect measurement, and the study setting (Blackhart et al., 2009). However, these mixed findings may also reflect differences in perceived relational evaluation. Most laboratory research manipulates social exclusion with strangers. This may result in subtle decreases in perceived relational evaluation because of a very brief or artificial relationship. Being excluded by a familiar source should invoke stronger decreases in perceived relational evaluation because of the inherit preexisting relationship. Indeed, the strongest effects of social exclusion on affect are found when participants imagine rejection with a familiar person

(Allen, Horne, & Trinder, 1996; Craighead, Kimball, & Rehak, 1979; Goldfried & Sobocinski, 1975) or are in the physical presence of others (Blackhart et al., 2009). These effects are significantly larger than being with unfamiliar others. This may be why romantic partners that break up report a “broken heart” or why the loss of a family member or close friend is shown to be the top source of stress in life (McAndrew, Akande, Turner, & Sharma, 2001).

The reflexive stage is also characterized by a diminished sense of four basic psychological needs: belonging, control, self-esteem, and meaningful existence (Williams, 2007). 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 belonging with others is necessary for survival and healthy functioning (Baumeister & Leary, 1995; Smart Richman & Leary, 2009). Social exclusion threatens the need to belong more clearly than other negative social interactions. For instance, the silent treatment more clearly threatens the need to belong than a verbal conflict (Williams & Zadro, 2005). The silent treatment offers no way to effectively interact with others. Verbal conflicts 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 and the content of the argument may not necessarily communicate relational devaluation (e.g., verbal argument over a mistake in sport).

One challenge with understanding the effects of social exclusion is that threats to the need to belong are often confounded with the need for control. The need for control is how individuals perceive control over their environment (Williams & Zadro, 2005). People who are

excluded may lose their sense of social self-efficacy because some exclusionary interactions have no obvious way to repair the relationship or regain inclusion. 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 (Buckley, Winkel, & Leary, 2004; Leary et al., 2006; Twenge, Baumeister, Tice, & Stucke, 2001; Twenge, Catanese, & Baumeister, 2002). Aggressive responses are likely when social exclusion is perceived to be unfair (Smart Richman & Leary, 2011). However, not all forms of social exclusion involve a deprived sense of control. Often in group conversations, some individuals are purposely ignored but can regain inclusion into the conversation by contributing a relevant comment. Researchers should be mindful of the exact paradigm they are using to manipulate social exclusion and how these events are perceived by individuals.

A third psychological need that may be affected by social exclusion is the need for self-esteem – how people perceive their own goodness and worth (Williams & Zadro, 2005). The sociometer hypothesis postulates self-esteem as a proxy for general perceptions of inclusion and motivates behaviors to minimize the potential of exclusion (Leary, Tambor, Terdal, & Downs, 1995). High self-esteem indicates higher perceptions of inclusion whereas low self-esteem indicates lower perceptions of inclusion. This hypothesis has received empirical support, with diminished self-esteem following an event of social exclusion (Buckley et al., 2004). However, this effect does not hold when findings are collectively analyzed using meta-analysis (Blackhart et al., 2009). This is because self-esteem may reflect a general sense of inclusion from an individual's broader social network. A one-off event of social exclusion may not necessarily impact an individual's self-esteem because self-esteem reflects inclusion from a broader network of relationships.

The fourth need that may be affected by social exclusion is the need for meaningful existence. This is how individuals need to be recognized for their existence to avoid purposelessness (Solomon, Greenberh, & Pyszczynski, 1991; Williams, 2007). Some forms of social exclusion where an individual is unable to respond to or reconcile social exclusion (e.g., deportation or solitary confinement) represent extreme cases of social punishment. In these instances, social exclusion can be like one is invisible or does not exist. This may leave individuals to question their purpose in a given context or, in the most extreme cases, life. Thus, some forms of social exclusion may be a subtle reminder of “social death” and impact the need for meaningful existence.

Reflective Stage

Threats to psychological needs are hypothesized to elicit specific coping strategies and motivate behavior depending on which needs are specifically impacted following social exclusion. This process represents the transition from the reflexive stage to the second stage of the temporal need threat model. The reflective stage occurs when an individual appraises the event. Coping with the affective impact and generating plans of action occur simultaneously while making sense of what happened. The stage is dependent on an individual’s ability to self-regulate thoughts, emotion, and behavior. In the moments following an event of social exclusion, effort is needed to assess, appraise, and attribute the meaning and importance of the event (Williams, 2009). Excluded individuals are hypothesized to respond in a self-regulatory manner to manage the effects of the reflexive stage.

Self-regulation is dependent on a higher order cognitive system known as cognitive control (Gray, 2004; Hoffman, Schmeichel, & Baddeley, 2012; Ochsner & Gross, 2005). Cognitive control is an umbrella term that represents top-down information processing to guide

behavior to meet intentions or goals (Diamond, 2013; Miller & Cohen, 2001). During the reflective stage an individual is tasked with appraising the event, regulating emotion, using information from the environment to generate plans of action and potentially executing those action plans – all of which place increased demands on cognitive control to manage the effects of social exclusion.

An area of interest during the reflective stage is how excluded individuals process and regulate the emotional effects of social exclusion (Riva, 2016). This is because cognitive control processes are part of a complex network involved in emotional processing to direct attention and resolve internal conflicts to support goal-related behavior (Possoa, 2017). Following social exclusion, there are specific emotion regulation strategies that vary in the demands they place on cognitive control (Riva, 2016). These demands vary in the amount of “pooled finite resources” they require – with greater demands tied to less available resources for other tasks and fewer demands tied to more available resources for other tasks. Specifically, rumination – repetitive focus on negative events and their probable causes and consequences (Berman, et al., 2011), and suppression – the conscious inhibition of emotional expressive behavior (Gross & Levenson, 1993) are understood to place stronger demands on cognitive control than more automated emotion regulation strategies (Ochsner & Gross, 2005).

Increased demands on cognitive control may result in impairments to logical reasoning and intelligent thought (Baumeister et al., 2002). These effects on cognitive control may be responsible for failures in self-regulation such as behaving aggressively (Twenge et al., 2001), being less prosocial (Twenge et al., 2007), and otherwise acting in self-defeating ways (Twenge et al., 2002). Social exclusion is thought to be quickly perceived and valued as a threat because social exclusion is deeply ingrained into the human psyche (MacDonald & Leary, 2005).

Cognitive resources are prioritized towards emotion processing and regulation systems (Chester & DeWall, 2014; Eisenberger, Lieberman, & Williams, 2003; Kawamoto, Nittono, & Ura, 2013; Otten & Jonas, 2013; Themanson, Khatcherian, Ball, & Rosen, 2013). Neuroimaging evidence suggests that cognitive control systems are activated to attend to and regulate the emotional reactions to social exclusion. However, this rapid detection and regulation of social exclusion comes at a cost. As attentional resources are classically viewed from a limited capacity framework (Hockey, 1997), resources are prioritized towards social exclusion and away from other salient tasks that require cognitive resources (e.g., behavior regulation, problem-solving).

Important concurrent tasks following social exclusion include appraising the environment, generating plans of action and executing those plans into overt behavior. There are less available cognitive control resources for these tasks because of the increased resource demands on cognitive control for regulating the effects of social exclusion. Research on the cognitive responses to social exclusion, specifically on cognitive control processes, is growing. However, research findings are mixed where some research indicates social exclusion directly impairs cognitive control processes (e.g., Baumeister et al., 2002; Buelow, Okdie, Brunell, & Trost, 2015), and other findings show social exclusion is simply not powerful enough to produce behavioral effects (e.g., Otten & Jonas, 2013; Themanson et al., 2013).

Despite these mixed findings, focusing on the effects of social exclusion on cognitive control remains important. There is evidence that cognitive control performance is linked to mental health, physical health, quality of life, school success, and job success (Diamond, 2013). A longitudinal study that followed people from birth found lower childhood self-control predicted depression, poorer physical health, less financial success, and higher rates of criminal conviction by 32 years of age (Moffitt et al., 2011). Research also shows cognitive control

performance to be positively associated with academic achievement among children (Morrison, Ponitz, & McClelland, 2010). Young children with higher performance on an array of measures of cognitive control at age four were more proficient in math and reading when followed up three years later (Bull, Espy, & Wiebe, 2008). Among 11- to 12-year-old children, working memory (a component interrelated with cognitive control) was positively associated with English and mathematics achievement, whereas inhibition (a component of cognitive control) was positively associated with English, mathematics, and science achievement (St Clair-Thompson & Gathercole, 2006). Given the importance of cognitive control performance to academic and developmental outcomes, the effects of social exclusion warrant consideration from a developmental perspective.

Developmental Aspects of Social Exclusion

Baumeister and Leary (1995) contend that social exclusion is adverse for all ages, yet, late childhood to early adolescence is a developmental period characterized by a heightened sensitivity to exclusion by peers (Bolling et al., 2011; Goodman, Stormshak, Dishion, 2001; Sebastian, Biding, Williams, & Blakemore, 2010). A *peer* is defined as a person who is equal to another with respect to certain characteristics such as age, background, educational level, skills, and social status (Fitzgerald, Fitzgerald, & Aherne, 2012; Smith, 2007). Social exclusion may be seen as a natural feature of development because peers assume a heightened developmental role in the lives of young people and present the potential to influence norms and behaviors (Killen, Mulvey, & Hitti, 2013; Smith, 2003). Along with the increased importance of peers, this developmental period is characterized by the development of self-regulation and cognitive skills (Diamond, 2013; Welsh, 1991). Changes in social orientation may be concurrent with structural and functional changes in brain areas that are associated with cognitive control (Blakemore,

2008; Fuhrmann, Knoll, & Blakemore, 2015; Nelson, Leibenluft, McClure, & Pine, 2005).

Studying the effects of social exclusion during this developmental period is important to understand how the immediate effects of social exclusion may contribute to maladaptive outcomes. Twenty-eight percent of young people report being excluded, rejected, or victimized (Robers, Kemp & Truman, 2013). Those who report these adverse social experiences also report psychosomatic symptoms (e.g., head/stomach ache & sleeping irregularity), have low self-esteem, display mental health problems (e.g., anxiety, depression, and suicidal thoughts), and perform poorly in school (Brunstein Klomeck, et al., 2007; Buhs, Ladd, & Herald, 2006).

The work that has investigated the effects of social exclusion in young people is generally guided by the notion that they are less efficient than adults at regulating the effects of social exclusion (Sebastian et al., 2010). Additionally, late childhood and early adolescence are unique from other developmental periods because it is widely recognized as hallmark transition period for young people where there is an increased investment in creating social relationships with peers and an expansion of social networks outside of the family. The potential of social exclusion contributing to ill-being is greatest among young people for these reasons. Research supports this developmental perspective (Abrams, Weick, Thomas, Colbe, & Franklin, 2011). Social exclusion has strong negative effects on pleasant affect and a sense of belonging among 10- to 14-year-olds (Ruggieri, Bendzen, Gabriel, & Alsaker, 2013; Wölfer & Scheithaurer, 2014) with strongest effects on younger samples than teenagers or adults (Sebastian et al., 2010). Cognitive science research with children has shown social exclusion results in impairments to cognitive control performance (Hawes et al., 2012). These decrements in performance may be due to the demands of regulating the immediate effects of social exclusion. Following an event of social exclusion, cognitive control systems are activated to cope and regulate affect, attention, appraisals, and

generate plans of action. Therefore, any additional tasks following social exclusion that require the same cognitive control systems likely compete for available resources. Neuroscientific evidence shows that brain networks associated with cognitive control processes are activated during and following social exclusion (Bolling et al., 2011; Guyer, Choate, Pine, & Nelson, 2012; van Noordt, White, Wu, Mayes, & Crowley, 2015). These findings suggest that adolescents begin to regulate the effects of social exclusion, but these systems may be less efficient than those of their adult counterparts and may contribute to impairments in cognitive control.

Effects of Physical Activity and Aerobic Fitness on Affect and Cognitive Control

Decreased pleasant affect is a hallmark effect of social exclusion. Behaviors that enhance affective states may help mitigate subsequent negative effects of social exclusion. A large body of research suggests short bouts of physical activity can enhance pleasant affect (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000; Ekkekakis & Petruzzello, 1999; Reed & Ones, 2006). *Physical activity* is any movement produced by the skeletal muscles resulting in energy expenditure (Caspersen, Powell, & Christenson, 1985). Most of this work has been conducted with adults, but there is evidence to suggest young people experience similar affect enhancement following a single bout of physical activity. Williamson, Dewy, and Steinberg (2001) found 15 minutes of aerobic physical activity results in increases in positive affect and decreases in negative affect among nine- to 10-year-old children. Among 14- to 16-year-olds, a 30-minute bout of aerobic physical activity resulted in increases in pleasant affect during and 10 minutes after the cessation of physical activity (Schnieder, Graham, Grant, King, & Cooper, 2009).

These effects of short bouts of physical activity on affect are explained by the dual-mode theory (Ekkekakis, 2005; 2009; Ekkekakis, Hall, Petruzzello, 2004). The dual-mode theory

suggests that affective responses to a single bout of physical activity are influenced by the intensity of the physical activity as a function of an individual's intensity tolerance (i.e., ventilatory threshold) as well as cognitive and somatic cues. At low intensities of physical activity that require aerobic metabolism (e.g., light-to-brisk walking), affective responses are typically pleasant and homogeneous across individuals. According to the dual-mode theory, the physiological demands of low-intensity physical activity are evolutionarily adaptive (Ekkekakis et al., 2004). Pleasure became associated with this adaptive intensity because of its evolutionary function and importance (Ekkekakis, 2005).

Physical activity is also useful to impact cognitive control performance. Cognitive control is involved in the regulation of effects of social exclusion and found to be impaired after being excluded (Baumeister et al., 2002; Hawes et al., 2012). Accumulating evidence suggests that short bouts of aerobic physical activity have a beneficial effect on cognitive control performance (Chang et al., 2012; Lambourne & Tomporowski, 2010; Roig, Nordbrandt, Geertsen, & Nielsen, 2013). This work is generally guided by the *executive-control hypothesis* (Colcombe & Kramer, 2003; Hall, Smith, & Keele, 2001). The executive-control hypothesis posits that physical activity will have its greatest benefits on cognitive processes that require the most effort, especially among people who are cognitively developing, delayed, declining, or impaired (Colcombe & Kramer, 2003; Hall et al., 2001). In support of the executive-control hypothesis, meta-analytic evidence suggests physical activity has the largest effects on tasks requiring effortful cognitive processes such as those associated with cognitive control (Chang et al., 2012; Lambourne & Tomporowski, 2010; Roig et al., 2013), with recent evidence directly supporting this hypothesis among young people (Drollette et al., 2014).

There is evidence that children show a similar pattern of benefits to cognitive control as

adults (Best, 2010; Donnelly et al., 2016; Sibley & Etnier, 2003). Research shows that a 20-minute bout of walking improves response accuracy and reading comprehension among preadolescent children (Hillman et al., 2009). Pontifex and colleagues (2013) showed a 20-minute bout of aerobic physical activity improved response accuracy and stimulus-related processing relative to a sedentary control condition among 40 preadolescent children with and without a formal diagnosis of attention-deficit hyperactivity disorder (ADHD). Importantly, both groups of children showed similar physical activity benefits to cognitive performance as well as improvements on standardized tests of reading and arithmetic. Other research has shown that short bouts of physical activity result in a maintenance effect of cognitive control performance among preadolescent children such that physical activity buffers against performance decline when remaining sedentary (Drollette, Shishido, Pontifex, & Hillman, 2012).

While the etiology of acute physical activity effects on cognitive control performance is debated, a plausible explanation is offered by the *cognitive-energetic model* (Audriffen, 2009; McMorris, 2008). The cognitive-energetic model proposes that physical activity arouses brain areas associated with cognitive control performance following the cessation of activity (Audriffen, 2009; McMorris, 2008). Single bouts of aerobic physical activity of light-to-moderate intensity are hypothesized to alter brain systems that change the allocation of cognitive resources to meet task demands, thereby leading to improvements in cognitive performance (Audriffen, 2009). Evidence from neuroimaging research suggests that improvements in behavioral performance coincide with more efficient activation of the anterior cingulate cortex, characterized by increased activation in the frontal lobes and beneficial effects when measured with event-related potentials (Hillman et al., 2009, Kamajo, Nishihira, Higashiura, & Kuroiwa, 2007; Li et al., 2014). These modulations of brain activity are therefore thought to mediate

observed improvements in behavioral performance.

When physical activity is repeated over time, the effects of physical activity on cognitive control follow a similar beneficial pattern as single bouts (Donnelly et al., 2014). The strongest evidence comes from randomized control trial research. Kamijo and colleagues (2011) found that the effects of a nine-month afterschool physical activity program improved a component of cognitive control performance known as working memory for young children seven to nine years old. Hillman and colleagues (2014) studied the effects of the same nine-month afterschool physical activity program with another cohort of children and found small positive effects of physical activity on two components of cognitive control (i.e., inhibition and cognitive flexibility). An important aspect to chronic fitness activity interventions is that they have the potential to improve an aspect of physical health known as aerobic fitness. *Aerobic fitness* is a health-related component of physical fitness that relates to the ability of the circulatory and respiratory systems to supply fuel during sustained physical activity and to eliminate fatigue products after supplying fuel (Caspersen et al., 1985). Both studies showed improvements in aerobic fitness for children receiving physical activity compared to wait-list controls. Focus on the association between aerobic fitness and cognitive control performance is important because of the beneficial role of circulatory and respiratory systems in brain function and health (Hillman et al., 2008)

Findings show that higher aerobic fitness is associated with greater cognitive performance, brain structure and function (Chaddock, Pontifex, Hillman, & Kramer, 2011; Chaddock, Voss, & Kramer, 2012). A growing body of cross-sectional studies show higher levels of aerobic fitness are associated with improved cognitive control performance among children (Chaddock, Hillman, Buck, & Cohen, 2011; Chaddock et al., 2012; Drollette et al.,

2016; Kao, Westfall, Parks, Pontifex, & Hillman, 2016; Hillman, Castelli, & Buck, 2005; Pontifex et al., 2011). Children with higher levels of aerobic fitness show larger volumes of brain structures associated with cognitive control (Chaddock et al., 2010) and greater white matter integrity than children with lower levels of aerobic fitness (Chaddock-Heyman et al., 2014). These differences in brain structure volume were shown to mediate the association of aerobic fitness with cognitive control performance, suggesting a potential mechanism to explain the beneficial role of aerobic fitness on cognitive performance (Chaddock et al., 2010). Improving aerobic fitness is especially important for children because it can also lead to global enhancements in well-being and academic achievement (Chu, Chen, Pontifex, Sun, & Chang, 2016; Ortega, Ruiz, Castillo, Sjöström, 2008).

Exploring Physical Activity and Fitness to Address Responses to Social Exclusion

Physical activity is a unique behavioral strategy to address the effects of social exclusion. First, there appears to be considerable overlap between the intensities of physical activity shown to boost affect and cognitive performance such that low-to-moderate physical activity may be able to address both affective and cognitive responses to social exclusion. Second, single bouts of aerobic physical activity are flexible enough to be used both proactively and reactively – as some forms of social exclusion may be predictable (i.e., sports team ‘cuts’ scheduled on a particular date) whereas others may be spontaneous and unanticipated (i.e., being rejected on a school playground). Third, physical activity behaviors of low-to-moderate intensity (e.g., walking, cycling) are practical and feasible because they are accessible to most people to incorporate into their daily lives with low burden and cost.

Not all events of social exclusion are predictable which presents a challenge if single bouts of physical activity are to be used preemptively or reactively. An individual may wish to

use physical activity as avoidant or distracting behavior following an event of social exclusion. Research shows that engaging in a distracting task following social exclusion speeds up recovery from social exclusion compared to ruminating about it (Wesselmann, Ren, Swim, & Williams, 2013). Using physical activity to avoid or distract from the effects of social exclusion may also offer new social opportunities, especially when physical activity is group based (e.g., dance, fitness classes, sport). However, social exclusion has been shown to promote lethargic behavior (Twenge et al., 2003), predict reduced physical activity over time among adults (Hawkley et al., 2009), and decrease the amount of physical activity and increase the amount of sedentary behavior in young children (Barkley, Salvy, & Roemmich, 2012). Using physical activity as a reactive strategy may detract from the overall quality of physical activity despite its utility to boost pleasant affect, enhance cognitive performance, and speed up recovery.

Physical activity can be useful as a preemptive strategy to reduce affective and cognitive consequences when social exclusion can be predicted (e.g., tryouts for sport teams or school plays, employment opportunities, asking another person for a first date). Even when social exclusion cannot be predicted, repeated single bouts of physical activity may be useful to protect against subsequent social exclusion throughout the day. Study one draws from this perspective that a single bout of walking may protect from the affective and cognitive effects of subsequent unexpected social exclusion.

Beyond behavioral strategies such as single bouts of physical activity to address social exclusion, there is value in exploring activity related attributes such as aerobic fitness. Aerobic fitness is a powerful marker of health for young people (Ortega et al, 2008) and is tied to greater psychological well-being and academic achievement (Chu et al., 2016). Individuals with higher aerobic fitness may be able to better manage the affective and cognitive responses to social

exclusion. This may be especially important for young people to potentially counteract the development of maladaptive outcomes when excluded. Study two draws from this perspective, that aerobic fitness may be an important moderator that dampens the affective and cognitive effects of social exclusion.

Through these two studies, this dissertation explores the role of health-related factors to address the immediate effects of social exclusion. It utilizes an interdisciplinary approach informed by social psychology, exercise psychology, cognitive and affective science, and human development. The present dissertation is novel and exploratory, offering a foundation to direct future research with practical ways to reduce the adverse effects of social exclusion.

CHAPTER 2: STUDY ONE

DOES WALKING MITIGATE AFFECTIVE AND COGNITIVE RESPONSES TO SOCIAL EXCLUSION?

Preface

This manuscript was accepted for publication in the *Journal of Sport & Exercise Psychology* in 2017. Complete citation: Delli Paoli, A. G., Smith, A. L., Pontifex, M. B. (2017). Does walking mitigate affective and cognitive responses to social exclusion? *Journal of Sport & Exercise Psychology*. doi: 10.1123/jsep.2016-0202. Human Kinetics holds the copyright of the manuscript and its contents. Under this copyright, the authors explicitly reserve the right to use all or part of this article in future works of their own, such as dissertations, lectures, reviews, or textbooks.

This study started as the practicum research project of the first author (Delli Paoli, A. G.), under the direction of the coauthors (Smith, A. L. & Pontifex, M. B.). The project was presented with a preliminary sample size of $n = 60$ in April 2015 at Michigan State University in East Lansing, MI and with the full sample size of $n = 96$ in October 2015 at the Society for Social Neuroscience in Chicago, IL. The first author coordinated the study, collected data and analyzed results. All authors contributed to the conceptual design of the study and edits and revisions of the manuscript.

Abstract

Social exclusion can produce harmful affective and cognitive responses that undermine healthy functioning. Physical activity is known to have acute affective and cognitive effects that are adaptive, and therefore may mitigate these responses. The purpose of this study was to assess walking as a strategy to reduce the effects of social exclusion on affect and working memory performance. Healthy female college students ($N = 96$, $M_{\text{age}} = 19.2 \pm 0.8$ years) were randomly assigned to one of four experimental conditions: (a) sedentary plus neutral feedback, (b) sedentary plus exclusion feedback, (c) walking plus neutral feedback, or (d) walking plus exclusion feedback. Pre and post activity and pre and post feedback measures of affect and working memory performance were recorded. Excluded participants had a significant negative shift in affect following feedback, $p < .05$. Those who were sedentary prior to exclusion had lower affect scores following exclusion than the walking plus exclusion and the neutral feedback groups, $p < .05$. There were no direct effects of walking or social exclusion on working memory. However, perceptions of being ignored predicted smaller improvements in working memory performance for participants who were sedentary prior to exclusion, $p < .05$. The findings suggest that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions that can undermine working memory. More broadly, this work supports continued examination of physical activity as a potential strategy for helping individuals cope with negative social experiences.

Introduction

People have a fundamental need to form and maintain stable, meaningful, and lasting relationships (Baumeister & Leary, 1995). Indeed, people strongly desire acceptance and social bonds with others, frequently devote attention to the status of their relationships and behave in ways to maintain and protect their relationships (Baumeister & Leary, 1995). Yet, social life is dynamic and exclusion experiences are common. New college students often feel left out of social opportunities, text messages go unanswered, students leave classmates out of group work, and romantic partners break up. These and other experiences reflect social exclusion, a process where a person is put into a condition of being alone or is denied social contact, thwarting that person's inherent need to belong (Blackhart, Nelson, Knowles, & Baumeister, 2009).

Social exclusion is harmful to psychological, physical, and interpersonal functioning (Baumeister, DeWall, Ciarocco, & Twenge, 2005; Cacioppo & Hawkley, 2009; Hawkley, Thisted, & Cacioppo, 2009; Twenge, Baumeister, DeWall, Ciarocco, & Bartels, 2007). Often underpinning such negative outcomes are transient effects on self-regulation systems (Baumeister et al., 2005; Baumeister, Twenge, & Nuss, 2002). Social exclusion is hypothesized to influence self-regulatory systems through affective and cognitive responses to social exclusion. For instance, people who are excluded typically report "hurt feelings" (MacDonald & Leary, 2005) and demonstrate impairments to cognitive functioning (Baumeister et al., 2002). Using proactive strategies that target transient affective and cognitive responses may be an important first step to reducing harmful outcomes. Currently, there exist few proactive strategies that target these responses (Baumeister, Brewer, Tice, & Twenge, 2007).

One approach to using proactive strategies is to find ways to enhance affect and cognitive performance prior to an event of social exclusion. Accumulating evidence shows that acute bouts

of aerobic physical activity enhance affect and cognitive performance, making physical activity a potentially attractive proactive strategy (Chang, Labban, Gapin, & Etnier 2012; Reed & Ones, 2006). The present study specifically investigated the utility of walking, a widely accessible form of physical activity, to mitigate both affective and cognitive responses to social exclusion.

Affect is a simple, nonreflective feeling that is consciously accessible (Barrett, Mesquita, Ochsner, & Gross, 2007; Russell, 2003; Russell & Barrett, 1999). Affective states range along a continuum from pleasant to unpleasant valence, with pleasant feelings tied to helpful or rewarding events and unpleasant feelings tied to hurtful or threatening events (Panksepp, 1998; 2005). Research suggests that social exclusion generally leads to less pleasant and more unpleasant affective states compared to neutral social interactions (Blackhart et al., 2009). The immediate effect of social exclusion is characterized by a shift away from pleasant toward unpleasant valence, with this shift not extending past a neutral state of affect. One rationale for why social exclusion does not produce a shift beyond neutral affect is that individuals immediately begin a process of coping after being excluded (Blackhart et al., 2009; Williams, 2009).

Coping with an affective state is a form of self-regulation that is cognitively demanding, requiring an individual to continuously monitor and use corrective action to manage the affective state (Gross, 2013). A higher order self-regulatory system known as cognitive control enables this regulation (Gray, 2004; Ochsner & Gross, 2005), with working memory being a component of this system that is particularly salient following social exclusion events. Working memory is the process of manipulating information when it is no longer perceptually present (Baddeley, 1992; Diamond, 2013), which is critical for making sense of events that unfold over time and in formulating plans of action. Ideally, plans of action that afford the best chances of regaining

acceptance should be helpful and prosocial. Unfortunately, this may be difficult after social exclusion because helpful plans of action are effortful and require working memory to be unabated. Following social exclusion, impairments to working memory may be responsible for poor plans of action such as behaving aggressively (Twenge, Baumeister, Tice, & Stucke, 2001), being less prosocial (Twenge et al., 2007), and otherwise acting in self-defeating ways (Twenge, Catanese, & Baumeister, 2002).

Baddeley and Hitch's (1974) conceptual model posits that working memory has a limited capacity. Events that capture and direct attention require cognitive control systems (i.e., the central executive) in working memory to either amplify or inhibit perception, attention, and plans of action for these specific events (Baddeley, 2013). In the moments following social exclusion, working memory capacity is taxed from the self-regulation resource demands of managing affect, attention, perceptions, and potential plans of action. Thus, these increased demands draw from a finite pool of self-regulatory resources. This impairs cognitive control performance (Baumeister et al., 2002), with recent work showing working memory-specific decrements (Buelow, Okdie, Brunell, & Trost, 2015).

Strategies to mitigate the impact of social exclusion may serve to reduce demands on self-regulatory resources. Given that social exclusion experiences are common in daily life, such strategies should be applicable to a wide range of people to incorporate into their daily lives with little burden. Accumulating evidence shows that short bouts of aerobic physical activity increase pleasant affect and enhance cognitive performance (Chang et al., 2012; Lambourne & Tomporowski, 2010; Reed & Ones, 2006), making physical activity a potentially attractive strategy for addressing the affective and cognitive responses to social exclusion.

Extant work shows that short (10 to 40 minutes) bouts of light to brisk walking are associated with shifts from baseline affective states toward pleasant affect (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000; Ekkekakis & Petruzzello, 1999; Reed & Ones, 2006). Immediately after a short bout of walking, individuals report feeling more pleasant and energized, while recovery from walking has a calming and relaxing effect (Ekkekakis & Petruzzello, 1999). Research also suggests that single bouts of walking and cycling of similar intensity are associated with positive effects on working memory performance (Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009; Martins, Kavussanu, Willoughby, & Ring, 2013; Weng, Pierce, Darling, & Voss, 2015). Meta-analytic evidence shows short bouts of aerobic exercise to have significant positive effects on short-term memory, a subprocess of working memory (Roig, Nordbrandt, Geertsen, & Nielsen, 2013). Moreover, one study exploring both affective and cognitive responses to a short bout of cycling found increases in pleasant affect and working memory performance (Hogan, Mata, & Carstensen, 2013). Altogether, findings indicate that short bouts of aerobic physical activity may positively impact both affect and working memory performance.

In light of these findings, walking might be useful in addressing the effects of social exclusion. By enhancing affect and working memory prior to an event of social exclusion, an acute bout of walking may mitigate the demands for self-regulatory resources by limiting effort expenditure for managing the effects of social exclusion. Accordingly, the purpose of this study was to assess the effect of 20 minutes of walking prior to social exclusion on affect and working memory performance. We hypothesized that social exclusion would decrease pleasant affect and working memory performance. We also hypothesized that walking prior to social exclusion would mitigate the effects of social exclusion on affect and working memory, resulting in a more

pleasant affective state and higher working memory performance than social exclusion without walking.

Method

Participants

Ninety-six female college-aged adults (24 per condition, $M_{\text{age}} = 19.2 \pm 0.8$ years) from Michigan State University completed the study (see Appendix A). The sample was delimited to female participants to hold the sex composition of the experimental sessions constant, a strategy that is in line with previous social exclusion research (Maner, DeWall, Baumeister, & Schaller, 2007). During recruitment, prospective participants were informed that they would be involved in a study investigating the link between exercise and aspects of team building. Employing a cover story is in line with previous work (Nezlek, Kowalski, Leary, Blevins, & Holgate, 1997; Maner et al., 2007) and is necessary to ensure that natural responses to social exclusion are observed. There were 127 enrollees, however, those reporting contraindications to physical activity or a history of depression, neurological health issues, brain trauma, or concussion with loss of consciousness were excluded from participation in the study ($n = 31$). Most participants identified as not Hispanic (94.8%), White (85.4%), and right handed (91.7%) with normal (52.1%) or corrected-to-normal vision (47.9%). A portion (26%) of participants reported knowing another participant during the same visit (i.e., out of the four participants per data collection visit). Participants who identified knowing another participant reported their relationship as 12.5% infrequently/acquaintances, 8.3% frequently/regular acquaintances, and 4.2% very frequent/close friends. One participant did not disclose the type of relationship. The distribution of familiar or unfamiliar participants was not significantly different among

experimental conditions, $X^2(3) = 1.89, p = .60$, and the distribution of the nature of the reported relationship did not differ among experimental conditions, $X^2(9) = 7.11, p = .63$.

Measures

Affective Valence. In line with previous investigations of affective responses to social stimuli (Armstrong, McClenahan, Kittle, & Olatunji, 2014), we utilized the Empirical Valence Scale (EVS; Lishner, Cooter, & Zald, 2008) to measure affective valence (see Appendix B). The EVS is a one-item 200 mm bipolar scale that assesses affective valence. Participants were asked to place a mark along a continuous visual analog scale corresponding to how they currently felt, ranging from “most unpleasant imaginable” to “most pleasant imaginable.” EVS scores range from -100 to 100, corresponding to mm away from the center *neutral* point. Negative scores indicate unpleasant valence and positive scores indicate pleasant valence. The EVS contains the following descriptors in both valence directions from the *neutral* 0-point: *barely* (7 mm), *slightly* (12 mm), *mildly* (24 mm), *moderately* (38 mm), *strongly* (70 mm), *extremely* (85 mm), and *most imaginable* (100 mm). Two independent raters using a metric ruler scored responses in millimeters. When two raters were discrepant (e.g., differing by 1 mm), a third independent rater was used to determine the appropriate score between the two raters. Initial interrater agreement between two independent raters was 91.4%.

Working Memory. In line with previous investigations of working memory, we utilized a serial *n*-back task (Drollette et al., 2016). The *n*-back task asks participants to identify if the current stimulus matches or does not match a stimulus presented *n* trials previously (Carlson et al., 1998; Kirchner, 1958). Trials contained one of six 3.4 x 3.4 cm uniquely colored shape stimuli (i.e., green circle, red crescent, blue cross, purple star, orange square, yellow triangle). Shapes were presented on a 15.4-inch laptop screen (Dell Vostro 3500) against a black

background for 250 ms with a 2500 ms intertrial interval. Participants completed a 1-back block followed by a 2-back block containing a random order of 24 matching and 47 nonmatching trials per block. Matching trials in the 1-back block were trials containing a shape that matched the shape immediately preceding it. Matching trials in the 2-back block were trials containing a shape that matched the shape two trials preceding it. Participants responded on a two-button response pad (X-keys XK-24 keypad) with a left button press if the current shape did not match or a right button press if the shape did match the shape presented n -trials previously. The 2-back block places greater demands on working memory than the 1-back block. Analyses were conducted using d' (D prime) as a measure of memory sensitivity. This performance measure was calculated by taking the difference between the standardized hit rate (the number of matching trials correctly identified relative to the total number of matching trials) and the standardized false alarm rate (the number of nonmatching trials incorrectly identified as matching relative to the total number of nonmatching trials); $z[\text{hit rate}] - z[\text{false alarm rate}]$. Prior to standardization, a constant of 0.5 was added to the number of hits and false alarms and a constant of 1.0 added to the total number of matching and nonmatching trials (e.g., hit rate = $[\text{hits} + 0.5]/[\text{total matching trials} + 1]$) to remove the potential for undefined values (Verde, MacMillan, & Rotello, 2006). Larger d' values indicate a greater ability to discriminate between matching and nonmatching stimuli, suggestive of better working memory performance.

Experimental Conditions

Activity. Participants assigned to the sedentary activity were asked to sit quietly at a table for 20 minutes. Participants assigned to the walking activity completed a five-minute warm up on a motor-driven treadmill and were asked to continue walking at or above 60% of their age-predicted heart rate max ($220 - \text{age}$) on a 1.0% incline for an additional 15 minutes. This

intensity is of light to moderate physical activity (i.e., a brisk walk) and is in line with exercise research showing positive effects on affect and cognition (Chang et al., 2012; Ekkekakis & Petruzzello, 1999; Lambourne & Tomporowski, 2010; Roig et al., 2013). All participants watched a neutral educational video clip (Cooter, Holt, & Lachmann, 2011) on a 15.4 inch laptop (Dell Vostro 3500) at eye level during the assigned activity to remove the potential for psychosocial confounds between sedentary and walking activities (Pontifex, Parks, Henning, & Kamijo, 2015). Heart rate was recorded at two-minute intervals throughout each activity as a manipulation check.

Feedback. For the social exclusion manipulation, four participants engaged in a group meeting adapted from the get-acquainted paradigm (Nezlek et al., 1997). First, participants with nametags met together in a room to get to know one another by taking turns orally answering a list of basic questions presented on a sheet of paper (e.g., name, hometown, academic major). After the meeting, research assistants separated participants into private rooms. For each respective participant, a research assistant instructed her to choose two other participants from the group that she would most like to work with for a subsequent partner task. The research assistant briefly left the room and the participant wrote the names on a worksheet. The research assistant then returned to retrieve the names and then again left the room under the guise of comparing responses of the other participants and determining partner groups. Upon returning to the room, the research assistant gave false feedback to the participant about the partner task. Participants receiving neutral feedback were told, *“We won’t be doing the partner task for a while. In the meantime, I’m going to have you complete some additional tests and questionnaires.”* Participants receiving social exclusion feedback were told, *“I hate to tell you this, but no one chose you as someone they wanted to work with. So because of that you will have*

to independently complete additional tests and questionnaires.” This manipulation took approximately 15 minutes from the start of the group meeting to the end of feedback. As in previous investigations assessing the effectiveness of social exclusion manipulations (Zadro, Williams, & Richardson, 2004), a two-item questionnaire (Williams, 2009) was administered at the end of the study as a manipulation check for experimental feedback (see Appendix C). This questionnaire assesses perceptions of social exclusion. That is, participants reported the degree they perceived being ignored and excluded, respectively, on a scale of one, *not at all*, to five, *extremely*.

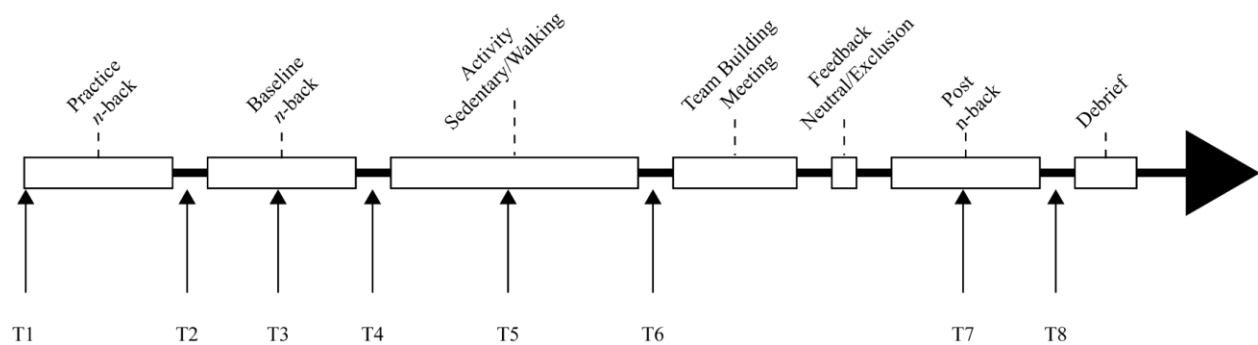


Figure 1. Procedural timeline. T = time point corresponding to affect assessment. Labels above rectangles indicate specific events. HR measured immediately prior to T1, at two-minute intervals across the activity portion of the study, and prior to completing each block of the n-back task. Scale of events and spacing of time points are roughly consistent with time of an overall session.

Design and Procedure

A mixed design was utilized with one between-subjects independent variable (i.e., Experimental Condition: sedentary plus neutral feedback, sedentary plus exclusion feedback, walking plus neutral feedback & walking plus exclusion feedback) and one repeated-measures independent variable (i.e., Time). This design allowed for the analysis of changes in affect and working memory performance over the course of the study as well as condition comparisons. Although a within-subject design for condition comparisons possesses certain advantages, between-subjects designs are preferred in social exclusion research because repeated exposures

to social exclusion conditions in a lab setting can reveal the purpose of the study and undermine natural responses to social exclusion.

After providing informed consent, participants completed demographics, health-screening, and physical activity readiness questionnaires online. Qualifying participants received an email to confirm their visit for data collection. Under the cover of an exercise and team building study, four participants were concurrently scheduled with participants randomly distributed to the four experimental conditions. All data were collected with four participants per experimental session. If fewer than four participants arrived for a scheduled data collection visit (due to individual participant cancellations or no shows, $n = 6$ scheduled data collection sessions), all participants were rescheduled for a later visit. A team of research assistants greeted participants upon arrival and individually escorted each participant to a randomly assigned private room. Upon entering the room, participants were fitted with a Polar® heart rate (HR) monitor (model H7, PolarElectro, Finland) and baseline HR was recorded after being seated for two minutes. HR was also measured at two-minute intervals across the activity portion of the study as well as prior to completing each block of the n -back task (to ensure within 10% of baseline HR value). After baseline HR was recorded, the first of eight EVS reports was completed (time point 1). Remaining EVS reports were provided at key study benchmarks: after practice n -back tasks (time point 2), after the pretest 1-back task (time point 3), after the pretest 2-back task (time point 4), halfway through the activity portion of the study (time point 5), after the activity portion (time point 6), after the posttest 1-back task (time point 7), and after the posttest 2-back task (time point 8). After the first EVS, participants completed one block each of the 1-back and 2-back versions of the n -back task for practice. This was repeated two additional times, once prior to the activity portion (pretest) and again following the activity portion and

feedback (posttest). Each block of the *n*-back task took approximately five minutes to complete with instruction and breaks in between blocks. Figure 1 displays the procedural timeline for an experimental session.

Following the walking or sedentary activity, participants were escorted to a separate room for the group meeting. After the group meeting, research assistants individually escorted participants back to their original private rooms, left the room for 60 seconds after asking participants to select partners on the worksheet, returned to gather the worksheet and left the room again for 60 seconds, and then returned to the room to deliver false feedback. After participants received false feedback about the partner task, participants immediately completed post assessment *n*-back tasks and the final EVS measures (once after 1-back block, once after 2-back block).

Following administration of the final EVS, each participant independently completed the social exclusion manipulation check, was verbally debriefed, and provided the opportunity to ask any questions, respectively. After verbal debriefing, participants signed an additional debriefing and consent to use data form. The full experimental session lasted approximately 90 minutes.

Statistical Analysis

Data were screened in line with best practice using IBM SPSS v22.0 (Tabachnick & Fidell, 2013). As a check for random assignment, we analyzed differences among experimental conditions on affect at time point 1 and performance on the pretest 1-back and 2-back working memory tasks with three separate one-way ANOVA models. As a manipulation check for the activity portion of the study, we analyzed differences among experimental conditions on mean HR with a one-way ANOVA. As a manipulation check for the feedback portion of the study, we analyzed differences among experimental conditions on perceptions of being ignored and

excluded, respectively, with one-way ANOVA models. Feedback manipulation checks were further analyzed to assess any influence of familiarity among participants within an experimental session. All significant effects were followed up with post hoc pairwise comparisons.

To measure differences in affect among experimental conditions across the experiment, we conducted a 4x8 mixed analysis of variance (ANOVA) with Experimental Condition (sedentary neutral, sedentary exclusion, walking neutral, & walking exclusion) as the between-subject factor and Time (time points 1 through 8) as the within-subject factor. Because our *a priori* interests were in differences across activity and feedback portions of the experiment, we focused subsequent analyses on affective measures during those portions (time points 5 through 8). First, we computed a composite measure by averaging initial, practice, and pretest affect scores (time points 1, 2, 3, and 4) to reduce the influence of multicollinearity among these baseline measures of affect. We included the composite measure in subsequent follow-up models as a covariate. This was to control for any potential influence of initial affect or testing reactivity (Holdwick & Wingenfield, 1999) prior to the activity manipulation. Thus, the following models control for these baseline measures of affect to provide a clearer observation of the experimental manipulation effects. The primary follow-up model was a 4x4 mixed analysis of covariance (mixed ANCOVA) with Experimental Condition (sedentary neutral, sedentary exclusion, walking neutral, & walking exclusion) as the between-subject factor and Time as the within-subject factor (time points 5, 6, 7, & 8) after controlling for baseline affect.

Secondary follow-up models dissected the Experimental Condition by Time interaction from the primary follow-up model with a series of ANCOVA models. To assess pairwise within-subject effects (i.e., shifts in affect), we conducted three 4x2 mixed ANCOVA models with Experimental Condition (sedentary neutral, sedentary exclusion, walking neutral, & walking

exclusion) as the between-subject factor and Time (time points 5 vs. 6, 6 vs. 7, 7 vs. 8) as the within-subject factor after controlling for baseline affect. To assess differences among experimental conditions for each time point, we conducted four one-way ANCOVAs with Experimental Condition (sedentary neutral, sedentary exclusion, walking neutral, & walking exclusion) as the between-subject factor after controlling for baseline affect. All models used a family-wise alpha level of .05, Greenhouse-Geisser correction for nonsphericity, and partial η^2 as a measure of effect size that is useful for research using covariates as control variables (Cohen, 1973; Tabachnick & Fidell, 2013).

We used two mixed 4x2 ANOVA models to examine performance in 1-back and 2-back working memory tasks, respectively, with Experimental Condition (sedentary neutral, sedentary exclusion, walking neutral, & walking exclusion) as the between-subject factor and Time (pre vs. post) as the within-subject factor. Lastly, we explored associations among affect, perceptions of being ignored and excluded, and pre-to-post changes in working memory performance with bivariate correlations.

Given the number of hypothesis-driven and exploratory analyses, we utilized the Benjamini and Hochberg (1995) false discovery rate control method to adjust for type I error and identify potential false positive results (see Glickman, Rao, & Schultz, 2014). There were 98 total probability tests conducted for the study. We used a false discovery rate of 0.05 (i.e., acknowledging 5 in 100 significant findings may be potential false positives). Findings that did not pass the Benjamini and Hochberg false discovery rate control method (BH-FDR) are noted in the results.

Results

Table 1.
Means and Standard Deviations for Manipulation Check Variables

	Sedentary Neutral	Sedentary Exclusion	Walking Neutral	Walking Exclusion
<i>Variable</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Heart Rate (BPM)	73.7 (15.0) ^a	71.9 (11.6) ^a	126.5 (5.4) ^b	127.0 (4.7) ^b
Ignored	1.0 (0.2) ^a	2.2 (1.1) ^b	1.0 (0.2) ^a	2.5 (1.5) ^b
Excluded	1.1 (0.3) ^a	2.7 (1.2) ^b	1.0 (0.2) ^a	2.5 (1.4) ^b

Note. Different superscripts across row indicate significant pairwise difference at $p < .001$.

Randomization and Manipulation Checks

Affect upon entering the study, $F(3, 92) = 0.7, p = .53$, partial $\eta^2 = 0.02$, working memory performance on the pretest 1-back task, $F(3, 92) = 0.9, p = .43$, partial $\eta^2 = 0.03$, and working memory performance on the pretest 2-back task, $F(3, 92) = 1.4, p = .25$, partial $\eta^2 = 0.04$, were not significantly different among experimental conditions, suggesting successful random assignment.

Mean HR during the activity portion was significantly different among experimental conditions, $F(3, 92) = 226.9, p < .001$, partial $\eta^2 = 0.88$. Participants recorded a mean HR of 126.5 ± 5.4 BPM (63% HR_{max}) in the walking neutral, 127.0 ± 4.7 BPM (63% HR_{max}) in the walking exclusion, 73.7 ± 15.0 BPM (37% HR_{max}) in the sedentary neutral, and 71.9 ± 11.6 BPM (36% HR_{max}) in the sedentary exclusion conditions. Participants in both walking conditions walked at the prescribed intensity and participants in both sedentary conditions remained within 10% of baseline HR. Post hoc tests (see Table 1) revealed that participants in both walking conditions recorded higher mean HR than participants in both sedentary conditions.

Perceptions of being ignored were significantly different among experimental conditions, $F(3, 92) = 15.7, p < .001$, partial $\eta^2 = 0.34$. Post hoc tests revealed that participants in both exclusion conditions reported higher perceptions of being ignored than participants in both

neutral conditions. Perceptions of being excluded were significantly different among experimental conditions, $F(3, 92) = 21.9, p < .001$, partial $\eta^2 = 0.42$. Post hoc tests revealed participants in both exclusion conditions reported higher perceptions of being excluded than participants in both neutral conditions. There was no evidence that knowing another participant had a main effect on reports of being ignored, $F(1, 95) = 0.04, p = .83$, or moderated the effect of experimental condition on reports of being ignored, $F(3, 88) = 0.03, p = .99$. There was also no evidence that knowing another participant had a main effect on reports of being excluded, $F(1, 95) = 1.1, p = .26$, or moderated the effect of experimental condition on reports of being excluded, $F(3, 88) = 0.4, p = .70$.

Affective Valence

The omnibus test revealed a significant main effect of Time, $F(7, 86) = 13.3, p < .001$, partial $\eta^2 = 0.13$, and a significant Experimental Condition by Time interaction, $F(21, 264) = 3.6, p < .001$, partial $\eta^2 = 0.11$ (see Figure 2). The primary follow-up model revealed a significant Experimental Condition by Time interaction, $F(9, 273) = 3.2, p < .01$, partial $\eta^2 = 0.09$. Thus, reports of affective valence were significantly different over activity and feedback portions of the study among experimental conditions after controlling for baseline affect. Secondary follow-up models focusing on time point shifts revealed a significant Experimental Condition by Time interaction for the shift in affect from before to after the feedback (i.e., from time point 6 to 7) after controlling for baseline affect, $F(3, 91) = 4.1, p < .01$, partial $\eta^2 = 0.12$. Post hoc pairwise comparisons (see Table 2) revealed a significant shift in affect for participants in the sedentary exclusion condition and in the walking exclusion condition, $p < .05$. Participants in the sedentary exclusion condition reported a large shift, $d = -.80$, from an affective state corresponding to between slightly and mildly pleasant toward neutral affect. Participants in the walking exclusion

condition reported a moderate shift, $d = -.62$, from an affective state corresponding to just above mildly to above slightly pleasant. However, the walking exclusion condition finding should be interpreted with caution because it did not pass the BH-FDR.

Secondary follow-up models (controlling for baseline affect) focusing on specific time

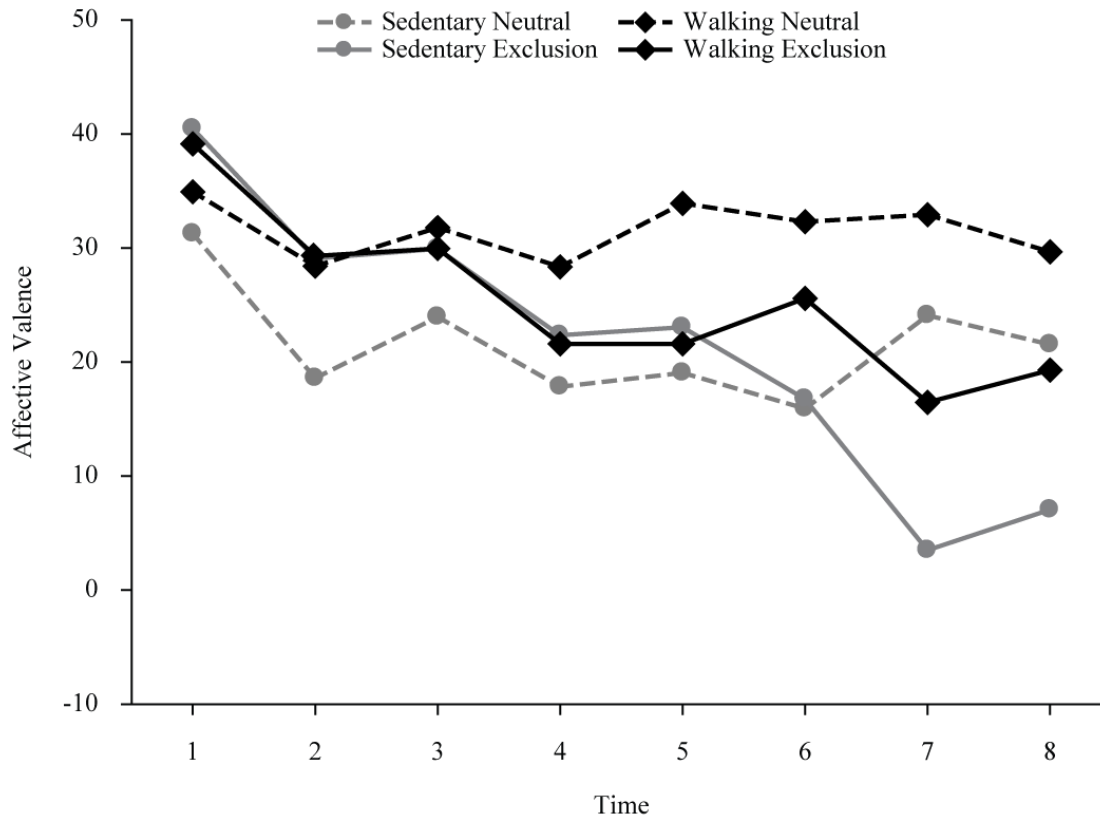


Figure 2. Affective valence by experimental condition over time. Positive values for affective valence reflect pleasant valence, negative values reflect unpleasant valence, and neutral is zero. Neutral and social exclusion feedback occurred between time points six and seven. Spacing of time points is roughly consistent with timing of an overall session.

points after feedback revealed differences in affective valence among experimental conditions at both time points seven, $F(3, 91) = 11.7, p < .001$, partial $\eta^2 = 0.28$, and eight, $F(3, 91) = 6.2, p < .001$, partial $\eta^2 = 0.17$. Post hoc pairwise comparisons for time point seven revealed participants in the sedentary exclusion condition reported the lowest affect (just above neutral), followed by

the walking exclusion condition (between slightly and mildly pleasant), and lastly both the sedentary neutral and walking neutral conditions (between mildly and moderately pleasant). Findings at time point seven should be interpreted with caution because comparisons of the walking exclusion condition with the sedentary exclusion condition and sedentary neutral condition, respectively, did not pass the BH-FDR. For time point eight, participants in the sedentary exclusion condition reported lower affect (at barely pleasant) than all other experimental conditions (around mildly pleasant). However, the comparison of the sedentary exclusion condition with the walking exclusion condition did not pass the BH-FDR and should be interpreted with caution.

Table 2.

Means and Standard Deviations for Affective Valence Scores in Follow-up Models

<i>Model</i>	Sedentary Neutral	Sedentary Exclusion	Walking Neutral	Walking Exclusion			
Time Point(s)	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>F</i>	<i>p</i>	η^2
<i>Shifts in Affect Across Adjacent Time Points</i>							
Time 5-6	-3.1 (10.9)	-6.3 (16.9)	-1.6 (10.6)	4.0 (16.4)	2.24	.089	.07
Time 6-7	8.2 (25.1)	-13.3 (23.6)*	0.6 (19.5)	-9.1 (20.9)*	4.14**	.009	.12
Time 7-8	-2.5 (9.7)	3.5 (8.8)	-3.3 (23.7)	2.8 (12.5)	1.26	.292	.04
<i>Between Conditions at Individual Time Points</i>							
Time 5	19.0 (28.1)	23.0 (27.9)	33.9 (24.9)	21.6 (33.1)	1.65	.183	.05
Time 6	15.9 (30.5)	16.8 (32.1)	32.3 (30.6)	25.6 (31.9)	1.77	.158	.06
Time 7	24.1 (21.6) ^c	3.5 (28.4) ^a	32.9 (24.2) ^c	16.5 (31.0) ^b	11.67***	.000	.28
Time 8	21.5 (22.8) ^b	7.0 (30.2) ^a	29.7 (29.0) ^b	19.3 (31.0) ^b	6.23***	.000	.17

Note. * = $p < .05$. ** = $p < .01$. *** = $p < .001$. partial η^2 = variance accounted for in follow-up models. For shifts models, positive values reflect movement toward more pleasant valence and negative values reflect movement toward more unpleasant valence. For individual time point models, different superscripts across a row indicate significant between-condition pairwise differences at $p < .05$. Time point five was during, and time point six followed, the sedentary or walking activity. Neutral and social exclusion feedback occurred between time points six and seven.

Working Memory

For the 1-back task, there was no evidence of a main effect of Time, $F(1, 92) = 0.2$, $p = 0.62$, partial $\eta^2 = .00$, Condition, $F(3, 92) = 1.6$, $p = 0.20$, partial $\eta^2 = 0.05$, nor a Condition by Time interaction, $F(3, 92) = 0.66$, $p = 0.57$, partial $\eta^2 = 0.02$. For the 2-back task, there was no evidence of a main effect of Condition, $F(3, 92) = 1.2$, $p = 0.30$, partial $\eta^2 = 0.04$, nor a Condition by Time interaction, $F(3, 92) = 0.8$, $p = 0.49$, partial $\eta^2 = 0.03$. However, a main effect of Time, $F(1, 92) = 21.9$, $p < .001$, partial $\eta^2 = 0.19$, indicated that all participants improved their working memory performance for the 2-back task regardless of experimental condition. Table 3 displays the mean performance for n -back tasks across the experiment.

Table 3.
Means and Standard Deviations for Working Memory Performance

Task	Sedentary Neutral		Sedentary Exclusion		Walking Neutral		Walking Exclusion	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
1-back	3.2 (1.0)	3.2 (0.9)	3.2 (0.6)	3.3 (0.5)	3.1 (0.6)	3.3 (0.7)	2.9 (1.0)	2.8 (0.8)
2-back	2.2 (0.8)	2.8 (1.0)	2.3 (0.6)	2.6 (0.9)	2.3 (0.6)	2.5 (0.9)	2.0 (0.7)	2.3 (0.9)

Note. Units are d' values. Higher values indicate greater working memory performance.

Associations of Affect and Exclusion Perceptions with Changes in Working Memory

Performance

There was no evidence that the affective shift from time six to seven or affective states at time points seven or eight correlated to pre-to-post changes in 1-back and 2-back working memory performance in any experimental condition (see Table 4). In addition, there was no evidence of perceptions of being excluded being associated with pre-to-post changes in working memory performance. However, higher perceptions of being ignored were associated with smaller pre-to-post changes in 2-back working memory performance for participants in the sedentary exclusion condition, $r = -.50$, $p < .05$, bootstrapped bias-corrected 95% CI [-.73, -.13]. Thus, perceptions of being ignored account for 25% of the variance in pre-to-post changes in 2-back working memory performance.

Table 4.

Associations among Affect and Exclusion Perceptions with Changes in Working Memory Performance

<i>Condition</i>	<i>Task</i>	Affective	Affect T7	Affect T8	Ignored	Excluded
		Shift				
Sedentary Neutral	Δ 1-back	-.34	-.31	-.27	.20	-.02
	Δ 2-back	.21	-.02	.06	.03	.25
Sedentary Exclusion	Δ 1-back	-.37	-.06	-.06	-.15	-.02
	Δ 2-back	.05	.20	.24	-.50*	-.14
Walking Neutral	Δ 1-back	.27	-.19	-.08	-.01	-.01
	Δ 2-back	.20	-.07	.14	-.15	-.15
Walking Exclusion	Δ 1-back	.02	.05	.11	-.22	-.03
	Δ 2-back	.02	.14	.18	-.17	-.06

Note. * $p < .05$. Affective shift = difference in affective valence between time six and time seven. Affect T7 = affective valence at time seven. Affect T8 = affective valence at time eight. Δ = changes in task performance (post – pre).

Discussion

The goal of the present study was to assess the effect of engaging in a short (20 minute) bout of walking prior to social exclusion on affect and working memory performance. Extant work shows social exclusion to stimulate maladaptive affective and cognitive responses, whereas short bouts of physical activity afford affective and cognitive benefits (Baumeister et al., 2002; Chang et al., 2012; Reed & Ones, 2006; Roig et al., 2013). We found that social exclusion results in a shift away from pleasant affect and walking appears to mitigate this affective response. Social exclusion did not directly influence working memory performance; however, perceptions of being ignored were associated with smaller improvements in working memory performance for those in the sedentary social exclusion condition.

We hypothesized that social exclusion would decrease pleasant affect and working memory performance. Participants in the exclusion conditions reported a noteworthy shift from pleasant toward neutral affect, aligning with extant meta-analytic findings (Blackhart et al., 2009). The majority of previous research has used single time point assessments of affect following social exclusion (Baumeister et al., 2002; Baumeister et al., 2005), whereas the present investigation captured affective shifts using repeated measures. By examining shifts within individuals, a rich understanding of affective responses to social exclusion was attained. For example, affect reported by participants in the sedentary exclusion condition declined following feedback and remained lower through time point eight. When comparing across conditions, affect following feedback was the lowest among those in the sedentary exclusion condition. These findings suggest that social exclusion has a substantive negative impact on pleasant affect and that affect may remain lower for several minutes following an event of social exclusion.

Although this investigation provided support for the affective portion of the first hypothesis, the direct effect of social exclusion on working memory was not supported. Social exclusion is hypothesized to place greater resource demands on higher order cognitive systems that manage affect and cognition, resulting in impairments to working memory performance (Baumeister et al., 2002; Buelow et al., 2015). The use of a high-functioning college-aged sample may explain this finding. These participants may possess a variety of automated self-regulation strategies based on experiencing social exclusion over their school-aged years. Automated self-regulation strategies may reduce resource demands following exclusion (DeWall et al., 2011; Ochsner, & Gross, 2005), potentially explaining why working memory performance was not directly impacted by social exclusion in the present study.

Despite this outcome, the results show that social perceptions may be tied to working memory performance, introducing an additional conceptual pathway for social exclusion effects on working memory. Reports of being ignored were negatively associated with changes in working memory performance for participants in the sedentary exclusion condition. Thus, impairments to working memory may vary to the degree an individual perceives being ignored. Increases in perceptions of social exclusion may stimulate intrusive thoughts, which could increase resource demands from the same finite pool of resources as working memory. Related research utilizing stereotype threat manipulations demonstrates intrusive thoughts and rumination to be associated with poorer working memory performance (Beilock, Rydell, & McConnell, 2007). Thus, a pathway to explore regarding cognitive effects is how social exclusion stimulates exclusion-related perceptions that may produce intrusive thoughts.

It is important to situate this finding relative to the magnitude of the reported social perceptions. Reports of being ignored and excluded did not cross the midpoint of the scale for

participants who received exclusion feedback. The getting to know you paradigm used in the present study likely constitutes a mild form of social exclusion. This noted, these levels of being ignored and excluded may also reflect underreporting of social exclusion perceptions.

Underreporting could be a defensive psychological strategy to blunt the averseness of social exclusion and to preserve self-worth (Twenge, Catenese, & Baumeister, 2003; Twenge et al., 2007). Indeed, previous research suggests that excluded participants tend to avoid self-awareness and report a neutral affective state (Twenge et al., 2003). Impaired working memory performance may require a degree of social exclusion that overpowers this defensive strategy.

Results also demonstrated no evidence of associations between affective states or shifts being related to working memory performance. This finding aligns with previous reports of no association between affective responses and behavioral outcomes of social exclusion (Twenge et al., 2001; 2003). The absent associations suggest that affective responses are an independent effect of social exclusion. The shift toward neutral affect may be an automatic and natural response to social exclusion, thereby placing little demand on self-regulation systems. The present results instead suggest that social exclusion perceptions may place resource demands on self-regulatory systems.

We also hypothesized that walking would mitigate the effects of social exclusion on affect and working memory, resulting in a more pleasant affective state and higher working memory performance than social exclusion without walking. Participants who walked prior to exclusion reported more pleasant affect following exclusion feedback than those who did not walk. Thus, a short bout of walking prior to social exclusion may have utility in reducing affective responses to social exclusion. Increases in calmness and relaxation have been observed during the period following physical activity, which might explain a potential mitigating role of

walking prior to social exclusion (Ekkekakis et al., 2000). Furthermore, walking prior to exclusion feedback may have dampened the association between perceptions of being ignored and working memory performance. Based on the BH-FDR results it is important to view the key study findings as tentative and preliminary. This caution acknowledged, there appears to be value in further exploring the potential for walking and other forms of physical activity in addressing social exclusion. Replication of findings will be necessary, and this exploration will be enhanced by directly addressing limitations of the present work.

Limitations and Future Research Directions

Though the present investigation shows that walking may help mitigate the effects of social exclusion, there are limitations that must be considered. For example, in the interest of not revealing the purpose of the study, we did not administer an assessment of affect directly upon providing the exclusion feedback. Rather, we administered our most proximal affect assessment following a block of the working memory task. When using deception in experimental research, researchers must decide on the appropriate time points to capture affective states without sacrificing the integrity of experimental manipulations. In light of these concerns, one solution for future research is to use implicit measures of affect (DeWall et al., 2011). These may be particularly useful to avoid revealing the purpose of the study to participants.

Also, as noted above, the use of a high-functioning college-aged sample likely produces a conservative estimate of effects. College-aged students may have already developed efficient coping strategies that buffer the impact of social exclusion. Future research may benefit from using a developing sample, such as adolescents, where social relationships with peers are of particular salience and self-regulation skills are developing.

An additional consideration in future work is that responses to exclusion may not be uniform, even if humans generally maintain a desire to feel included and share social bonds with others (Baumeister & Leary, 1995). Though we employed random assignment in the present study such that individual differences would be represented similarly across the conditions, there is value in attempting to directly assess individual difference variables that may moderate effects. Individual differences in affect regulation strategies (Gross & John, 2003), attachment styles (DeWall et al., 2012), loneliness (Cacioppo & Hawkley, 2009), need to belong (Beekman, Stock, & Marcus, 2016), and rejection sensitivity (Berenson et al., 2009) are examples that warrant exploration in future research.

Another consideration pertinent to all laboratory social exclusion research is if documented effects are the result of threats to the need to belong or a deprived sense of control. The social exclusion feedback in the current study is more controlling in tone than the neutral feedback and may have manipulated a participant's locus of control more so than the need to belong. Social exclusion comes in many forms and some involve feeling a loss of control (e.g., ostracism). Though certainly challenging because they are easily confounded, future research may benefit if the effects of social exclusion as a result of threats to the need to belong can be distinguished from those stemming from a deprived sense of control.

The present investigation did not replicate previous findings showing effects of single bouts of aerobic physical activity on working memory (Martins et al., 2013; Pontifex et al., 2009; Weng et al., 2015). This may be due to the amount of time that passed following the cessation of walking and the posttest assessment of working memory. Positive effects on working memory have been observed up to 30 minutes following the cessation of exercise and our posttest assessments were within this time-window (Pontifex et al., 2009). However, this time window is

not absolute due to the heterogeneity of research designs, exercise intensities, timing of administration, and type of cognitive assessment that make up the current literature base. Additional evidence is needed to understand if the effects of walking specific to working memory diminish as time passes.

As is common in budding research areas when there is interest in exploring an array of possible effects, a large number ($n = 98$) of probability tests were conducted in this study. Accordingly, results must be cautiously interpreted because of the potential for type I errors. In light of the large number of tests, we used the Benjamini and Hochberg (1995) false discovery rate control method to control for type-I error and identify potential false positive results. We found four potential false positive results out of 33 (12.1%) probability tests that satisfied the uncorrected criterion (i.e., $p < .05$). The findings will be important to attempt to replicate before drawing firm conclusions.

Lastly, the present work examined preemptive walking. When the potential for social exclusion is predictable, as with auditions for school plays, rushing a fraternity or sorority, or band or sport tryouts, walking may be particularly useful before an individual is potentially excluded. However, social exclusion events are not necessarily predictable. Examining the potential for physical activity to mitigate negative responses following a social exclusion event is also important. Physical activity could be useful as both a preemptive strategy and a reactive strategy for coping with social exclusion. In moving forward with this work, it will be critical to consider issues of timing and dose of physical activity, contextual factors, and other possible moderators of any effects.

Strengths and Conclusion

There are several notable strengths of the present study. Importantly, we demonstrated significant effects of social exclusion on affect even though we used a high-functioning college-age sample and a mild form of social exclusion. Moreover, we used a true control condition (i.e., neutral feedback), which is uncommon in social exclusion research. Social exclusion is typically juxtaposed with social inclusion (i.e., acceptance) in this research area. Comparing social exclusion with inclusion likely magnifies condition differences. The use of a repeated measures design is another unique study strength, enabling assessment of shifts in affect and changes in working memory. Manipulating social exclusion in a controlled laboratory setting captures the direct effects of social relationships and addresses some of the weaknesses of correlational designs more typically used in social relationships research. Finally, we investigated walking, a behavior with potential to address the effects of social exclusion. The practicality and feasibility of a walking intervention to assist in coping with social exclusion warrants continued consideration. Walking is a common form of physical activity that most individuals can incorporate into their daily lives with little burden. Considered together, we believe these study strengths have enabled us to provide a novel contribution to the respective exercise psychology and social relationships literatures.

In conclusion, this study suggests that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions with potential to undermine working memory. More broadly, this work supports continued examination of physical activity as a strategy for helping individuals cope with negative social experiences. Walking is a common form of active transport, especially on college campuses. Short bouts of walking throughout the day may mitigate subsequent affective consequences of social exclusion. However, the findings

reported here are preliminary and tentative, requiring replication and attention to study limitations. Important future avenues of research include exploring samples beyond university students, assessment issues, consideration of individual differences, and other matters surrounding how and when physical activity may mitigate maladaptive effects of social exclusion.

CHAPTER 3: STUDY TWO

DOES AEROBIC FITNESS MODERATE THE EFFECTS OF SOCIAL EXCLUSION ON AFFECT AND WORKING MEMORY AMONG FEMALE ADOLESCENTS?

Introduction

Late childhood and early adolescence are characterized by an increased interest in peers (Smith, 2003). Adolescents during this period begin to expand their social relationships outside of the family and making new friends increases in importance. However, not all children are successful in their pursuit of forging positive relationships with peers. A natural feature of this developmental period is adverse peer interactions such as social exclusion. Social exclusion is the process where a person is put into a condition of being alone or is denied social contact (Blackhart, Nelson, Knowles, & Baumeister, 2009). Social exclusion is associated with ill-being and poorer academic outcomes (Barkley, Salvy, & Roemmich, 2012; Brunstein Klomeck, et al., 2007; Buhs, Ladd & Herald, 2006; Cacioppo & Cacioppo, 2014; Newcomb, Burkowski & Pattee, 1993). These outcomes may result from repeatedly being excluded such that transient responses to social exclusion progressively impair healthy functioning. Factors that dampen the transient responses to social exclusion may aid in reducing impairments to healthy functioning. This study investigated whether aerobic fitness – an individual’s ability of the circulatory and respiratory systems to supply fuel during sustained physical activity and to eliminate fatigue products after supplying fuel (Caspersen, Powell, & Christenson, 1985) – mitigates the transient responses to social exclusion.

The maladaptive outcomes of social exclusion have been extensively studied in developmental, educational, and relationship science (e.g., Buhs et al., 2006; Newcomb et al., 1993). This body of research often views outcomes through a variety of social and psychological processes. Maladaptive outcomes may arise through restricted access to instrumental activities in

important developmental contexts, a lack of meaningful peer relationships, and indications that the individual is not valued by others. These processes may coincide with reduced efforts to establish new relationships with peers, withdrawal from group activities in contexts where exclusion is likely to occur, or aggressive behavior (Baumeister & Leary, 1995; Leary, 2001; Newcomb et al., 1993). Adolescents who are frequently socially excluded find themselves on a figurative “social perimeter” away from beneficial social experiences and deprived of the activities that serve to enhance their emotional, cognitive, and social functioning (Bowker, Adams, Fredstrom, & Gilman, 2014; Caccioppo & Caccioppo, 2014; Newcomb et al., 1993).

There is evidence that social exclusion may directly impact an adolescents’ emotional, cognitive, and social functioning. The temporal need threat model describes the transient emotional, cognitive, and behavioral responses following an event of social exclusion (Saylor et al., 2013; Williams, 2007; 2009). This model is a useful framework to understand the transient effects of many forms of social exclusion (e.g., neglect, ostracism, rejection) because all forms of social exclusion threaten an individual’s need to belong at their most basic level (Baumeister & Leary, 1995; Leary, 2001). The temporal need threat model postulates the transient effects of social exclusion occur in a progressive sequence of stages.

The first stage is labeled the reflexive stage whereby social exclusion is detected quickly as a threat to the need to belong (Baumeister & Leary, 1995; Williams, 2009). These immediate effects are characterized by a reduction in pleasant affect (Blackhart et al., 2009) and a diminished sense of the needs for belonging, self-esteem, control, and meaningful existence (Williams, 2009). Much of research has focused on adults; however, research documenting these effects in young children and adolescents indicates that they are more strongly affected by social exclusion than adults. For instance, Sebastian and colleagues (2010) found that compared to

young adults, adolescents between the ages of 11 and 13 showed the lowest level of pleasant affect after playing a computer game where they were socially excluded. One explanation for this finding is that adolescents may be more sensitive to the effects of social exclusion than adults because of their developing self-regulatory skills in combination with their heightened desire to establish relationships with peers (Diamond, 2013; Furhmann, Knoll, & Blakemore, 2015; Sebastian et al., 2010; Welsh, 1991).

Regulating the affective and psychological consequences of social exclusion occurs during the reflective stage. This stage is characterized by cognitive appraisals of the event, coping with affective and psychological consequences, making sense of what happened, and generating plans of action for how to respond. In the moments following an event of social exclusion, individuals must put forth effort to understand what happened and how to adaptively respond (Williams, 2009). Adaptive behaviors are characterized by prosocial behaviors that offer the best chances at regaining inclusion. Such prosocial behaviors may include becoming more agreeable, cooperative, or supportive. Unfortunately, not all people respond in an adaptive way. Children may respond to social exclusion with antisocial behavior such as withdrawing or behaving aggressively (Wölfer & Scheithaurer, 2013). Variety in responses to social exclusion may reflect an individual's ability to self-regulate emotions, thoughts, and behavior

Self-regulation is dependent on a higher-order cognitive system known as cognitive control (Gray, 2004; Hoffman, Schmeichel, & Baddeley, 2012). Cognitive control is an umbrella term that represents top-down information processing to guide behavior to meet intentions or goals (Diamond, 2013). Working memory is a component of cognitive control that is salient following social exclusion. Working memory is the ability to hold information in memory and make use of that information when it is no longer perceptually present (Baddeley, 1992;

Diamond, 2013). Working memory has been shown to play a crucial role in forging positive social relationships with peers from an early age (de Wilde, Koot, & van Lier, 2016) and is widely recognized as a predictor of scholastic performance and achievement (Bull, Espy, & Wiebe, 2008; Raghobar, Barnes, & Hecht, 2010; St Clair-Thompson & Gathercole, 2006). Social exclusion has been shown to impair working memory performance among adults (Baumeister, Twenge, & Nuss, 2002; Buelow, Okdie, Brunell, & Trost, 2015) and eight- to 12-year-old children (Hawes et al., 2012).

Impairments to working memory performance can be understood from a limited capacity framework (Baumeister et al., 2002; Hockey, 1997). In the moments following social exclusion, increased demands for cognitive resources are required to manage and regulate the effects of social exclusion. These resources are understood to be prioritized towards managing the emotional and psychological effects of social exclusion and away from other important cognitive tasks in a given context (e.g., deciding on how to respond, where attention should be directed). Indeed, neuroscientific evidence shows that brain networks associated with cognitive control and working memory processes are activated during and following social exclusion (Bolling et al., 2011; Guyer, Choate, Pine, & Nelson, 2012; van Noordt, White, Wu, Mayes, & Crowley, 2015). Impaired working memory performance may be explained by a competition for cognitive resources. Regulating the effects of social exclusion requires cognitive resources and therefore leaves fewer than required available cognitive resources to complete additional tasks. With a limited availability of cognitive resources, an adolescents' ability to perform other tasks that utilize working memory processes (e.g., attending to a teacher's instructions, enacting prosocial behavior) is diminished.

This limited capacity framework may be able to explain why some individuals respond to social exclusion in ways that are unhelpful. Reducing resource competition following social exclusion may enable working memory performance to remain intact and promote more adaptive responses. Research has documented that some college-aged adults respond in prosocial ways by either increasing cooperation, affiliating with others, or remembering greater amounts of social information (Gardner, Pickett, & Brewer, 2000; Maner, DeWall, Baumeister & Schaller, 2007; Williams & Sommer, 1997). These findings may be explained by a reduced competition for cognitive resources, thereby enabling individuals to utilize working memory in pursuit of adaptive responses. Importantly, a recent meta-analysis found that responses to social exclusion are sensitive to moderation (Hartgerink, van Beest, Wicherts, & Williams, 2015), suggesting potential value in exploring individual characteristics that may reduce resource competition following social exclusion. Investigating what characteristics enable preservation of working memory performance in the moments after exclusion may aid in highlighting the role of resource competition on cognitive performance.

Accumulating evidence shows higher levels of aerobic fitness are associated with improved cognitive control performance among young people (Chaddock, Hillman, Buck, & Cohen, 2011; Chaddock, Pontifex, Hillman, & Kramer, 2011; Chaddock, Voss, & Kramer, 2012; Drollete et al., 2016; Hillman, Castelli, & Buck, 2005; Kao, Westfall, Parks, Pontifex, & Hillman, in press; Pontifex et al., 2011; 2014). Specifically, Kao and colleagues (in press) showed a positive association between aerobic fitness and working memory performance among nine- to 11-year-olds. The fitness with cognitive performance association was shown to be mediated by the larger volumes of brain structures associated with cognitive control (Chaddock et al., 2010) and greater white matter integrity (Chaddock-Heyman et al., 2014). These findings

suggest youth with higher aerobic fitness may be able to more efficiently regulate the affective and psychological effects of social exclusion, thereby limiting effort expenditure, and leaving working memory performance unabated. Having working memory performance intact following an event of social exclusion may facilitate more adaptive responses to exclusion and potentially protect youth from maladaptive developmental outcomes.

The purpose of this study was to determine if aerobic fitness moderates affective and cognitive responses to social exclusion among children. Social exclusion is hypothesized to lower affect and working memory performance compared to social inclusion. The magnitudes of social exclusion effects are hypothesized to be dampened for participants with higher aerobic fitness compared to participants with lower fitness.

Methods

Participants

Participants were eligible for the study if female, between the ages nine to 12 years, able to perform physical activities based on the Child Physical Activity Readiness Questionnaire (CPAR-Q; Thomas, Reading, & Shepard, 1992), and possessing normal or corrected-to-normal vision. These inclusion criteria were chosen to remove sex as a between subject factor, to delimit the age range to late childhood, and for safety in completing the fitness assessment.

Thirty-seven participants and accompanying guardians completed the study; however, two participants were not included in the final analyses because they did not achieve any of the criteria for a successful aerobic fitness assessment. Therefore, the final sample consisted of 35 female participants (see Table 5). The final sample was 22.9% non-white and 8.9% Hispanic/Latina, 5.7% left-handed, and 34.3% requiring corrected vision. One child participant was reported to be on free or reduced lunch, 91.4% of participants' mothers had completed a bachelor's degree or higher and 71.4% of participants' fathers had completed a bachelor's degree or higher, and 97.1% of participants lived with both parents. Most (85%) participants were currently participating in sport with an average of 5.4 ± 3.4 hours spent in sport per week. A sensitivity analysis conducted using G*Power v3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007) revealed that the final sample size enabled detection of an effect size as small as Cohen's $d = .31$ at 80% power. This falls below previously published effect sizes that are large ($d > .89$) for the effect of social exclusion on affect and working memory performance with similar late childhood and adolescent samples (Hawes et al., 2012; Ruggieri et al., 2013; Sebastian et al., 2010; van Noordt, 2015).

Table 5.
Demographic Characteristics

Variable	Mean $\pm$ SD	Range
Age (years)	10.4 $\pm$ 1.2	9 – 12
Grade	5.2 $\pm$ 1.0	3 – 7
Birth Position	1.8 $\pm$ 1.2	1 – 7
ADHD Symptom Count	1.4 $\pm$ 2.7	0 – 14
Tanner Stage	1.8 $\pm$ 0.9	1 – 3.5
BMI (kg/m ²)	18.9 $\pm$ 3.8	14.5 – 29.6
BMI Percentile (%)	55.2 $\pm$ 28.4	1.6 – 99.2
V0 ₂ Max (ml/kg/min)	40.8 $\pm$ 7.0	20.9 – 53.5
V0 ₂ Percentile (%)	39.7 $\pm$ 32.0	3 – 93

Note: ADHD = attention-deficit hyperactivity disorder; BMI = body mass index; V0₂ Max = maximal oxygen consumption. BMI normative values provided by the Centers for Disease Control.

Design

A within-subject experimental design was used in the current study. This design allows for the comparison of participant responses to two experimental conditions: social inclusion and exclusion. Because manipulating social exclusion in laboratory settings involves deception, the order in which participants progress through experimental conditions are fixed to capture natural responses to social exclusion. In line with previous research that used social exclusion in within-subject designs (Bolling et al., 2011; Sebastian et al., 2010), participants were socially included by a computer game with virtual partners then played a second game where they were socially excluded. The fixed order of manipulations avoids negative spill-over effects and is less problematic than being excluded first then included (Sebastian et al., 2010). This design allowed for the comparison of dependent measures in response to two levels of social relationships.

Guardian Measures

Demographics and Activities of Child Participant. Guardians completed measures of the demographic characteristics, family environment, and activities of the child participant (Appendix E). Additionally, guardians completed the Attention Deficit Hyperactivity Disorder

Rating Scale IV (DuPaul, Power, McGoe, Ikeda & Anastopoulos, 1998) to assess the number of ADHD symptoms and the Tanner Staging System (Tanner, 1962) to assess the child participant's pubertal status. As a reflection of socioeconomic status, items asked guardians to report: (a) whether the child was on free or reduced lunch, (b) the educational status of adults in the home, and (c) the number of adults in the home who worked full-time. These measures were used for descriptive purposes.

Child Measures

Loneliness. The Children's Loneliness Scale (CLA) is one of the most widely used measures to assess perceptions of loneliness in children (Asher, Hymel, & Renshaw, 1984; Asher & Wheeler, 1985). The CLA consists of 16 primary items (e.g., "I feel alone") assessing loneliness perceptions and eight filler items (e.g., "I watch TV a lot") for a total of 24 items. All are rated on a 5-point Likert-type scale ranging from one "not at all" to five "always". Scores on the primary 16 items are summed for a total score of perceived loneliness that can range from 16 to 80. Construct validity and internal consistency of the 16 primary items are well-supported in the extant literature (Goossens & Beyers, 2016). The sum loneliness score and internal consistency value are reported in the results.

Social Exclusion Experiences. The Ostracism Experience Scale for Adolescents (OES-A) is an 11-item self-report measure that assesses perceptions of being ignored and excluded in daily life (Gilman, Carter-Sowell, DeWall, Adams, & Carboni, 2013). Child participants were asked to answer items with the following stem "In general others..." Items are rated on a one "never" to five "always" likert-type scale. The ignored subscale (e.g., "...ignored me during conversation") contains five items and excluded subscale (e.g., "...invite me to go out to eat with them") contains six items. This measure possesses high internal consistency, $\alpha = 0.93$ to 0.94 ,

construct, convergent, and discriminant validity among high school students (Gilman et al., 2013) and has been used with children as young as 12 years old (Niu, Sun, Tian, Fan, & Zhou, 2016). The mean ignored and exclusion subscale scores and internal consistency values are reported in the results.

Social Competence. The social competence subscale of the Self-Perception Profile for Children (SPPC; Harter, 1985; 2012) was used to assess perceptions of social competence. This measure utilizes a structured alternative format that is designed to counterbalance the tendency to report socially desirable responses (Harter, 1985; 2012). Participants were first asked to decide which of the two statements she was most like (e.g., “Some kids find it hard to make friends BUT Other kids find it’s pretty easy to make friends”). Once a participant decided which kind of kid she is most like, she then indicated if the description is “*really true for me*” or “*sort of true for me*”. Items were scored from one to four with higher scores indicating greater perceived competence. The social competence subscale scores have exhibited internal consistency reliability values ranging from 0.75 to 0.84, and have been found to be valid for child participants in grades three through five (Harter, 1985; 2012). The mean social competence subscale score and internal consistency value are reported in the results.

Affective Valence. The children’s feeling scale (CFS; Hulley et al., 2008) is designed to measure the affective states of children. The original CFS uses an 11-point bipolar rating scale ranging from -5 “*very bad*” to +5 “*very good*” with a 0 “*OK*” midpoint and representative picture faces. A modified CFS was used in the current study with a 9-point bipolar rating scale from -4 “*bad*” to +4 “*good*” with a 0 “*OK*” midpoint because extreme valence responses (i.e., “*very bad*”, “*very good*”) are uncommon in social exclusion research. Modifications also included updating the faces to emoji-based faces to make the scale more contemporary for the target sample than

the original CFS. Previous scale development was conducted and validity was supported by Hulley and colleagues (2008) with a sample of 5- to 10-year-old children. The CFS was used throughout the study to monitor child participants' affective valence prior to and immediately following the completion of each task. Measures prior to and immediately following tasks were used as dependent measures of affect in the study. All child self-report instruments can be found in Appendix F.

Working Memory. A modified serial n -back task was administered that involves two consecutive blocks including 1-back and 2-back blocks (Pellegrina et al., 2015). Each block required child participants to discriminate between 20 distinct consonant letter stimuli: B, C, D, F, G, H, J, K, L, M, N, P, Q, R, S, T, V, W, Y, and Z. Letter stimuli were presented one by one in the center of a computer screen. Participants completed a 1-back followed by a 2-back block containing a random order of matching and non-matching trials per block. Matching trials in the 1-back block are trials containing a letter that matched the letter immediately preceding it. Matching trials in the 2-back block are trials containing a letter that matched the letter two trials immediately preceding it. The 2-back block is more challenging in that it places greater demands on working memory than the 1-back block. Two sets of 40 (30 non-matching & 10 matching) trials were completed for each n -back test block. Each block used five random letter stimuli out of the 20 with a randomized order of trials within task blocks and equally probable presentation of stimuli (eight trials for each letter). All stimuli were approximately 3.4 cm tall presented one at a time on a black background on a computer screen for 500 ms with a fixed 3000 ms intertrial interval. This task was successfully used with children aged seven to 13 years in a large normative study (Pellegrina et al., 2015). Measures of matching trial accuracy (hit %), nonmatching trial errors (false alarm %), mean reaction time (ms), and memory sensitivity (d')

were used as dependent measures of working memory performance. The maximum d' score for this task is 3.8 using the Verde, MacMillan, and Rotello (2006) transformation.

Aerobic Fitness. Child participants completed a graded exercise test of maximal oxygen consumption ($\text{VO}_2 \text{ max}$) - the physiological limit to the rate at which an individual can deliver and consume oxygen. This graded exercise test is considered the criterion measure of cardiorespiratory fitness (American College of Sports Medicine, 2010). Maximal oxygen consumption was measured using a computerized indirect calorimetry system (ParvoMedics True Max 2400, Sandy, UT). Averages for VO_2 and respiratory exchange ratio (RER) were assessed every 20 seconds. A modified Balke protocol (American College of Sports Medicine, 2010) was followed using a motor-driven treadmill at a constant speed unique to each participant with increases in grade increments of 2.5% every two minutes until volitional exhaustion. A Polar heart rate monitor (Polar WearLink H7; Polar Electro, Finland) measured heart rate throughout the test. Ratings of perceived exertion were collected every two minutes using the children's OMNI scale (Utter, Robertson, Nieman, & Kang, 2002).

Attainment of $\text{VO}_2 \text{ max}$ was qualified based upon maximal effort as evidenced by either: (1) a peak heart rate $> 185 \text{ bpm}$ (American College of Sports Medicine, 2010) and a heart rate plateau as observed by an increase of less than five bpm despite an increase in workload (Freedson & Goodman, 1993), (2) RER greater than 1.0 (BarOr, 1983), (3) a score on the children's OMNI ratings of perceived exertion scale greater than seven (Utter et al., 2002), and/or (4) a plateau in oxygen consumption corresponding to an increase of less than 2 ml/kg/min despite an increase in workload. Participants' VO_2 normative percentile (Shvartz & Reibold, 1990) was used as a moderator in analyses because it accounts for female age differences in $\text{VO}_2 \text{ max}$ values.

Experimental Conditions

Cyberball 4.0 (Williams & Jarvis, 2006; Williams, Yeager, Cheng, & Choi, 2012) is an open-source virtual ball-toss game that is used to invoke social exclusion via computer. Cyberball involves three players, one of which is a participant and the other two are computer controlled. For purposes of this study, child participants were told a cover story that they will be playing a game of catch with two other children over the internet. The other two players were actually computer controlled confederates. Cyberball has been used in previous research to successfully elicit perceptions of social exclusion with children from seven to 12 years of age (Bolling et al., 2011; Hawes, et al., 2012; Zadro et al., 2013). In line with the recommendations of Zadro and colleagues, child participants were told to imagine they are actually tossing a ball with other children in real life. This was followed by questions from the research assistant to the child participant to aid in imagining playing a game of catch in real life (e.g., “Tell me where you are playing?”, “What kind of kids are you playing with?”, “What color is the ball?”). The number of ball passes and direction were fixed depending on whether the participant was included or excluded. In the exclusion condition the participant received the ball only twice within the first 10 throws out of 20 total throws (i.e. 10%). In the inclusion condition the participant received seven throws (i.e. 33%) evenly spaced throughout the 20 total throws. Also, as recommended by Zadro and colleagues, the two computer-controlled players were given sex-matched names. Names were chosen from publicly available data from the Social Security Administration for the most commonly given female names in 2006 (around when the participants were born) within the state where the study was conducted.

Manipulation Check. A three-item manipulation check derived from Zadro and colleagues (2013) assessed the effectiveness of the Cyberball game (Appendix G). Participants

were asked to respond to items “I felt happy”, “I felt sad” and “I felt ignored” on a one “*not at all*” to five “*very much so*” scale. Participants were asked to respond to these items about the Cyberball game they just played. This measure has been successfully used with Cyberball research involving children as young as eight years old (Hawes et al., 2012).

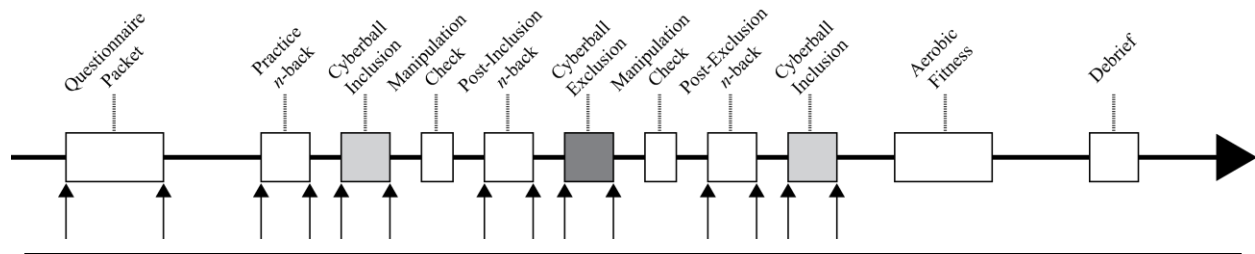


Figure 3. Procedural timeline. Labels above rectangles indicate specific events. Inclusion manipulations indicated by light grey boxes. Exclusion manipulation is indicated by the dark grey box. Arrows indicate measures of affective valence. Scale of events and spacing of time points are roughly consistent with time of an overall session.

Procedure

After receiving approval from the human research protection program (see Appendix D), child participants and guardians were recruited from the local community through email list serves and an advertisement flyer (see Appendix H). Guardians provided information over the phone to the study coordinator to screen child participants for eligibility and eligible participants were scheduled to visit the lab. Upon visiting the lab, guardians were asked to provide informed written consent and child participants were asked to provide written assent. After consent and assent were obtained, guardians and child participants were separated into private rooms. Once in a private room, guardians completed a questionnaire packet containing guardian measures. In the other room, child participants completed several tasks: the questionnaire battery assessing social relationships, a practice version of the working memory task, a Cyberball game where they were socially included immediately followed by manipulation checks, a second working

memory task, a second Cyberball game where they were socially excluded immediately followed by manipulation checks, and a third working memory task (see Figure 3). Following the third working memory task, child participants played a third Cyberball game where they were socially included (to mitigate potential extended negative feelings; Zadro et al., 2013). Measures of affective valence were administered before and after each task (except manipulation checks). Participants were offered a short break after each task. Following the third Cyberball task, child participants completed an assessment of aerobic fitness in a separate private room in the same building as the lab. Upon completion of the aerobic fitness assessment, child participants were compensated with a small token (i.e., pencil, pen, eraser, stickers) and \$15 gift card for participating.

Upon completion of these procedures, guardians and child participants were collectively verbally debriefed to offer full disclosure of the study purposes. After verbal debriefing, child participants and accompanying guardians were provided the opportunity to engage the research team in questioning. Finally, because the social exclusion component of the study was not disclosed prior to participation, a debriefing and consent to use data form was completed by guardians. No guardians or participants opted to withdraw their data from the study.

Statistical Analysis

Data were screened in line with traditional best practice (Tabachnick & Fidell, 2013). Descriptive analyses were conducted for all variables of interest. The manipulation check items in response to experimental conditions were evaluated with separate dependent *t*-tests with Condition (inclusion vs exclusion) as the within-subject variable.

Affective valence and working memory performance (hit %, false alarm %, mean reaction time, & d') in response to experimental conditions were first evaluated with a series of

dependent *t*-tests to address the main effect of social exclusion. These analyses used Condition (inclusion vs. exclusion) as the within-subject variable to assess changes in affective valence and working memory performance for the 1-back and 2-back tasks, respectively. Effect sizes, Cohen's d_{rm} , adjusted for the correlation of paired data and 95% confidence intervals (see Lakens, 2013; Nakagawa & Cuthill, 2007) are reported for all dependent *t*-tests (Cohen, 1973; 1988).

The role of aerobic fitness on affective valence and working memory performance in response to experimental conditions was evaluated by separate repeated measure analysis of covariance models (RM ANCOVA) with Condition (inclusion vs exclusion) as the within-subject variable, Aerobic Fitness as the covariate, and the interaction of Condition X Aerobic Fitness as the interaction term (Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009; Delaney & Maxwell, 1981). Working memory performance analyses used d' as the dependent measure because it accounts for overall task performance. The Condition X Aerobic Fitness interaction tests if participants with different levels of aerobic fitness show different inclusion to exclusion changes in dependent measures. A negative interaction term would indicate that more aerobically fit participants decrease more than less aerobically fit participants whereas a positive interaction term would indicate that more aerobically fit participants increase more than less aerobically fit participants. Partial η^2 was reported as an effect size in all RM ANCOVA models (Cohen, 1973; 1988). To interpret this correlation, change scores (exclusion – inclusion) were regressed on to Aerobic Fitness, after controlling for Age, and then plotted.

Results

Manipulation Checks

After being excluded, participants reported feeling less happy, $t(34) = -6.9, p < .001, d_{rm} = -1.6$, 95% CI[-2.2, -1.0], sadder, $t(34) = 5.4, p < .001, d_{rm} = 1.3$, 95% CI[0.7, 1.8], and more ignored, $t(34) = 13.8, p < .001, d_{rm} = 3.1$, 95% CI[2.3, 4.0], compared to being included. After being included again, participants reported feeling happier, $t(34) = 7.1, p < .001, d_{rm} = 1.5$, 95% CI[0.9, 2.0], less sad, $t(34) = -5.3, p < .001, d_{rm} = -1.1$, 95% CI[-1.6, -0.6], and less ignored, $t(34) = -13.3, p < .001, d_{rm} = -2.9$, 95% CI[-3.6, -2.1], compared to being excluded. There was no evidence that responses to manipulation check items were related to aerobic fitness, r 's = -.15 to .28, p 's $> .11$. Table 5 displays the manipulation check results.

Table 6.
Descriptive Statistics for Cyberball Manipulation Checks

Variable	Included	Excluded	Included
	$M \pm SD$	$M \pm SD$	$M \pm SD$
Happy	4.5 ± 0.7^a	3.1 ± 1.1^b	4.6 ± 0.9^a
Sad	1.0 ± 0.2^a	2.1 ± 1.2^b	1.1 ± 0.3^a
Ignored	1.1 ± 0.4^a	3.9 ± 1.2^b	1.3 ± 0.5^a

Note: Different superscript letters across a row represent a significant pairwise difference at $p < .001$.

Perceptions of Loneliness, Being Ignored and Excluded, and Social Competence

Participants' reports of loneliness, 24.2 ± 4.6 , and general frequency of being ignored, 1.4 ± 0.3 , and excluded, 2.3 ± 0.5 , in daily life were low whereas their perceptions of social competence were high, 3.4 ± 0.4 with respect to the respective measures' response scales. Internal consistency values were acceptable only for loneliness, $\alpha = .73$, and social competence measures, $\alpha = .68$, but not for reports of general frequency of being ignored, $\alpha = .48$, or excluded, $\alpha = .55$. There was no evidence that self-perception measures were related to aerobic fitness r 's = -.18 to .11, p 's $> .31$.

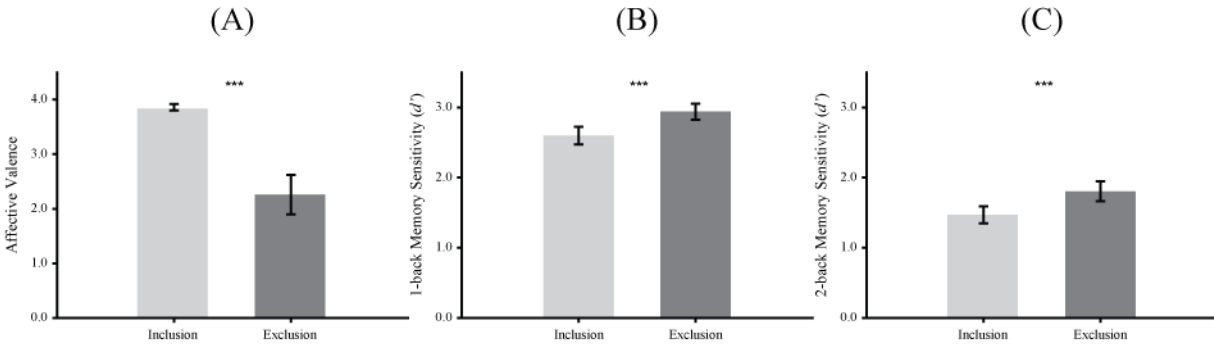


Figure 4. Affective responses and cognitive performance following inclusion then exclusion. Panel (A) affective valence. Panel (B) memory sensitivity (d') scores for the 1-back task. Panel (C) memory sensitivity (d') scores for the 2-back task. *** $p < .001$.

Affective Responses

Manipulations produced a small significant positive shift in affective valence from before to after being included, $t(34) = 2.3$, $p < .05$, $d_{rm} = 0.4$, 95% CI[0.1, 0.8], and a large significant negative shift in affective valence from before to after being excluded, $t(34) = -3.6$, $p < .001$, $d_{rm} = -0.8$, 95% CI[-1.3, -0.3]. Participants reported similar affective valence prior to each condition, $t(34) = 0.3$, $p = .79$, $d_{rm} = 0$, 95% CI[-0.2, 0.3]; however, large differences in reports of affective valence were found after each condition, $t(34) = -4.4$, $p < .001$, $d_{rm} = -1.0$, 95% CI[-1.5, -0.5] (see Figure 4, Panel A). After being included participants reported a mean of 3.9 ± 0.4 on the CFS, corresponding to a feeling state of good. After being excluded participants reported a mean of 2.3 ± 2.1 , corresponding to a feeling state of just above fairly good.

Working Memory Performance

Contrary to hypotheses, markers of working memory performance showed improvement from inclusion to exclusion (see Table 6). Performance on the 1-back task showed a lower false alarm rate, $t(34) = -2.9$, $p < .001$, $d_{rm} = -0.6$, 95% CI[-1.0, -0.2], faster response time, $t(34) = -2.5$, $p < .001$, $d_{rm} = -0.3$, 95% CI[-0.5, -0.1], and higher d' score, $t(34) = 2.8$, $p < .001$, $d_{rm} = 0.5$, 95% CI[0.1, 0.8] (see Figure 4, Panel B), after exclusion compared to after inclusion.

Performance on the 2-back task showed a higher hit rate, $t(34) = 3.9, p < .001, d_{rm} = 0.6$, 95% CI[0.3, 0.9], and higher d' score, $t(34) = 4.0, p < .001, d_{rm} = 0.4$, 95% CI[0.2, 0.6] (see Figure 4, Panel C), after exclusion compared to after inclusion.

Table 7.
Descriptive Statistics for Working Memory

Variable	1-back		2-back	
	Inclusion	Exclusion	Inclusion	Exclusion
	$M \pm SD$	$M \pm SD$	$M \pm SD$	$M \pm SD$
Hit %	86.9 $\pm$ 12.8 ^a	89.7 $\pm$ 12.5 ^a	66.3 $\pm$ 12.4 ^a	74.9 $\pm$ 15.4 ^b
False Alarm %	7.0 $\pm$ 6.9 ^a	3.5 $\pm$ 3.7 ^b	16.0 $\pm$ 12.4 ^a	14.1 $\pm$ 10.6 ^a
Response Time (ms)	812.8 $\pm$ 259.8 ^a	745.6 $\pm$ 216.4 ^b	965.7 $\pm$ 359.8 ^a	953.6 $\pm$ 378.5 ^a
d'	2.6 $\pm$ 0.7 ^a	2.9 $\pm$ 0.7 ^b	1.5 $\pm$ 0.7 ^a	1.8 $\pm$ 0.8 ^b

Note: Different superscript letters across a row represent a significant pairwise difference at $p < .05$ for the respective n -back task.

Aerobic Fitness and Responses to Social Exclusion

Aerobic fitness significantly moderated the effect of experimental condition on affective valence, $F(1, 33) = 6.4, p < .05$, partial $\eta^2 = .16$. This interaction revealed that there was a significant positive relationship between aerobic fitness and changes in affective valence from inclusion to exclusion, $\beta = .40$, bootstrapped bias-corrected 95% CI[.22, .58], $p < .05$, $\Delta R^2 = .16$ (see Figure 5, Panel A). The interaction revealed that more aerobically fit participants showed higher change scores than less aerobically fit participants. Relative to the amount of change, less aerobically fit participants showed greater decreases in pleasant affect than more aerobically fit participants. Affect after inclusion was not significantly related to changes in affect from inclusion to exclusion, $r = -.10$, bootstrapped bias-corrected 95% CI[-.44, .33]. Thus, level of affect prior to exclusion does not appear to have impacted change in affect after being excluded.

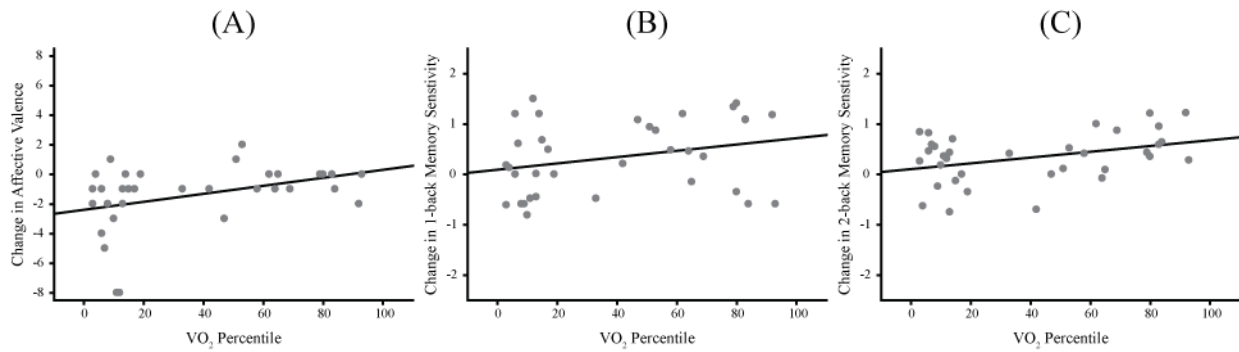


Figure 5. Fitness with changes in affective valence and working memory. Positive values along the y-axis represent increases from inclusion to exclusion and negative values represent decreases from inclusion to exclusion for dependent variables. Panel (A) shows changes in affective valence. Panel (B) shows changes in 1-back task performance. Panel (C) shows changes in 2-back task performance.

There was no evidence that aerobic fitness significantly moderated the effect of experimental condition on memory sensitivity from the 1-back task, $F(1, 33) = 2.7, p = .11$, partial $\eta^2 = .08$ (see Figure 5, Panel B). Performance on the 1-back task after inclusion was significantly negatively related to changes in 1-back performance, $r = -.58, p < .001$, bootstrapped bias-corrected 95% CI $[-.77, -.31]$. Thus, cognitive performance prior to exclusion negatively impacted change in cognitive performance after being excluded for the 1-back task.

However, aerobic fitness significantly moderated the effect of experimental condition on the more challenging 2-back task, $F(1, 33) = 5.2, p < .05$, partial $\eta^2 = .14$. This interaction revealed that there was a significant positive relationship between aerobic fitness and changes in memory sensitivity from inclusion to exclusion, $\beta = .37$, bias-corrected 95% CI $[.08, .61]$, $p < .05$, $\Delta R^2 = .14$ (see Figure 5, Panel C). The interaction revealed that more aerobically fit participants showed higher change scores than less aerobically fit participants. Relative to the amount of change, more aerobically fit participants showed greater increases in working memory performance than less aerobically fit participants. Performance on the 2-back after inclusion was not significantly related to changes in 2-back performance from inclusion to exclusion, $r = -.07$,

bootstrapped bias-corrected 95% CI[-.36, .21]. Thus, cognitive performance prior to exclusion does not appear to have impacted change in cognitive performance after being excluded.

Discussion

The goal of the present study was to determine if aerobic fitness moderates affective and working memory responses to social exclusion among adolescent girls. Research shows that social exclusion can produce maladaptive effects on affect and working memory (Hawes et al., 2012; Sebastian et al., 2010). Results provided supporting evidence that the effects of social exclusion appear most pronounced for adolescents with lower levels of aerobic fitness, whereas those with higher levels of aerobic fitness appear less affected by social exclusion. The collective affective and working memory results suggest that higher aerobically fit girls may be better able to regulate the demands of social exclusion than lower aerobically fit girls.

Manipulation check results showed social exclusion made participants feel less happy, sadder, and more ignored compared to social inclusion. These findings are consistent with the use of Cyberball with young people for producing mild social exclusion in a laboratory setting (Zadro et al., 2013). Manipulation check items returned to post-inclusion levels following the third game where participants were socially included supporting its use to mitigate any potential extended negative feelings. Importantly, manipulation check results were not related to aerobic fitness, suggesting participants perceived social exclusion similarly regardless of fitness level.

We hypothesized that social exclusion would decrease pleasant affect and working memory performance. Participants reported a negative shift in pleasant affect from feeling good to fairly good prior to and immediately after being socially excluded. The level of affective valence was also significantly lower than after being socially included. These results support previous meta-analytic findings that social exclusion can produce negative shifts in affect (Blackhart et al., 2009). This negative shift also aligns with adult literature, suggesting that laboratory manipulations of social exclusion reduce pleasant affect or good feelings, but are not

unpleasant or make participants feel bad overall (Blackhart et al., 2009; Delli Paoli, Smith, & Pontifex, in press).

This noted, results from manipulation check items showed participants felt sadder when being excluded compared to included. While participants did report feeling sadder, the mean level of sadness did not cross the midpoint of the scale after exclusion. Additionally, the distinction between measures of affective valence and the manipulation check items is important considering participants felt sadder. Affective valence measures assessed current feelings immediately after manipulations, whereas the “I felt sad” item assessed feelings during manipulations via recall. Specific feelings during the manipulations are likely confined to during the manipulation whereas the primary interest of the study was affective states following exclusion experiences. In line with the temporal need threat model (Williams, 2007; 2009), feelings immediately captured after social exclusion are a more appropriate measure of feelings for on-going regulation of emotion and cognition.

Cognitive performance results were opposite of our hypotheses. Overall, performance on both the 1-back and more challenging 2-back task was higher after exclusion compared to inclusion. Given the repeated measures design, this finding likely represents a practice effect. Performance gains may be a result of familiarity with and exposure to the working memory tasks. These findings conflict with previous research that social exclusion impairs working memory performance (Hawes et al., 2009). Social exclusion is hypothesized to place greater demands on cognitive control systems that are responsible for regulating emotional and psychological effects (Baumeister et al., 2002; Hawes et al., 2012). These greater demands are understood to compete for cognitive resources, thus resulting in impairments in other cognitively demanding tasks following exclusion (Pessoa, 2009; 2017). Despite the overall increase in

performance, the effects of experimental condition were moderated by aerobic fitness revealing that participants change differently based on their level of aerobic fitness.

Aerobic fitness was positively associated with changes in 2-back working memory performance. Importantly, changes in performance were not related to performance after inclusion, suggesting that findings are likely not due to regression to the mean. The positive association of fitness with changes in 2-back performance showed that those with higher levels of fitness displayed larger improvements in performance whereas those with lower levels of fitness showed smaller improvements in performance. Thus, one possibility for the tempered improvements among lower fit girls is that social exclusion may have tempered a practice effect on working memory performance. These tempered improvements in working memory performance were also accompanied by larger decreases in pleasant affect. Changes in affective valence were positively associated with aerobic fitness such that those with lower levels of fitness showed the larger decreases in affective valence, whereas those with higher levels of fitness showed smaller decreases in affective valence from inclusion to exclusion. Combined these findings reveal that the feelings of higher aerobically fit girls are not as strongly impacted by social exclusion and they are able to improve working memory performance to a greater degree than those with lower aerobic fitness. Higher aerobically fit girls may experience fewer demands on cognitive control systems to regulate the effects of social exclusion.

Deserving consideration is why aerobic fitness moderated changes in 2-back task performance and not 1-back task performance. One rationale for this finding is that the effect of aerobic fitness on 1-back task performance is small and given the sample size we were not sufficiently powered to detect such a small effect. A second rationale for this finding is that all participants showed similar performance improvements on the 1-back task regardless of aerobic

fitness because the task is not as cognitively demanding as the 2-back task. This is supported by the high mean performance on the task as well as research with adults that shows social exclusion impacts more challenging cognitive control tasks than less challenging ones (Baumeister et al., 2002). Additionally, performance after inclusion and changes in performance from inclusion to exclusion were negatively correlated. Given the high performance on this task, this result may reflect a ceiling effect whereby lower performers after inclusion were able to improve after exclusion whereas higher performers had little room to improve.

Situating the working memory findings in a laboratory context may aid in understanding why performance increased contrary to our hypothesis that performance would decrease. Although laboratory research provides a controlled setting to observe direct effects, manipulating artificial and new relationships in a laboratory setting may not be an accurate reflection how social exclusion operates outside of the lab. As mentioned and supported in previous research with adults, effects may be stronger when being socially excluded by actual other human beings who are physically present and valued by the targets of social exclusion (Blackhart et al., 2009). There may be a certain threshold that leads to impairments in working memory performance that may only occur when experiencing social exclusion from a familiar person. Laboratory manipulations of social exclusion involve deception and may not reach this threshold because ethical and practical concerns limit social exclusion manipulations to mild forms and the use of artificial social relationships. These artificial relationships may not as strongly resonate with participants as being excluded from an existing social relationship (i.e., best friend at school, sport teammate). For example, social relationship difficulties with peers at school are likely more disturbing to a child than social exclusion from a computerized ball-toss game.

A related consideration is there may have been a low demand for cognitive resources because working memory tasks were completed after exclusion ended. This sequence of study tasks provided the participant with no opportunity for reparative behavior with the other virtual players. Any action planning for responsive behavior is unlikely without this opportunity. Demands on cognitive resources may be higher in an ongoing social interaction where an individual must put forth effort to plan behaviors and process ongoing social information to help regain inclusion (Williams, 2009).

Despite no opportunity for reparative behavior, there remains the potential for a heightened demand for cognitive resources after social exclusion ends. Demands for cognitive resources may have increased following exclusion depending on how participants regulated their feelings. Previous research suggests that suppression (Richards & Gross, 2000) and rumination (Beilock, Rydell, & McConnel, 2007) place demands on cognitive resources and are linked with weakened memory performance. However, reappraisal has been linked with improved recovery times from social exclusion (Sethi, Moulds, & Richardson, 2013) and more adaptive interpersonal functioning (Gross & John, 2003). Therefore, observed changes in cognitive performance may be related to how participants regulated their feelings after exclusion.

Important to consider are the theoretical and developmental implications of the study. Williams's temporal need threat model (2007; 2009) indicates the effects of social exclusion occur in a series of stages. The results of this study show that aerobic fitness moderates the effects of social exclusion on the reflective stage (i.e., on-going regulation of affect and working memory). Girls with higher aerobic fitness may be less negatively impacted because they are able to more efficiently regulate effects of social exclusion. Therefore, aerobic fitness may have the potential to protect against maladaptive outcomes throughout development. Developing a

child's aerobic fitness may counteract reduced efforts to make new friends, withdrawal from social activities, and behaving aggressively as well as make them less likely to be on a "social perimeter" in important developmental settings (Baumeister & Leary, 1995; Bowker et al., 2014; Caccioppo & Caccioppo, 2014; Leary, 2001; Newcomb et al., 1993). Furthermore, aerobic fitness was positively associated with greater improvements in working memory performance, suggesting that improving a child's aerobic fitness may benefit academic (Bull et al., 2008; Raghubar, et al., 2010; St Clair-Thompson & Gathercole, 2006) and social functioning (de Wilde, Koot, & van Lier, 2016).

The results of this study indicate that there is value in improving a child's aerobic fitness. Aerobic activities of moderate-to-vigorous intensity that are sustained like running, jogging, and bicycling can improve aerobic fitness. These can be accomplished at school in physical education or through participation in aerobic and endurance-based team sports. Sports such as cross-country, soccer, or swimming among others can benefit aerobic fitness as well as provide meaningful opportunities for positive social relationships with peers (Smith, 2003). Thus, sport that is appropriately structured can offer health benefits while fulfilling the need to belong in ways that contribute to well-being (Smith & Delli Paoli, in press; Verhagen, Lodder, & Baumeister, in press). This noted, the interpretation and implications of results are tentative and preliminary. Replication and extension of key study findings will be required by addressing several avenues for future research.

Limitations and Future Research Directions

A key limitation of the present study is the absence of a control arm where participants complete procedures without exclusion (i.e., consecutive inclusion conditions). Adding such an arm in future research would help contextualize how social exclusion potentially impacts

working memory performance. For instance, a practice effect may be greater under consecutive inclusion conditions than inclusion followed by exclusion conditions. This would indicate that social exclusion tempers performance improvements that would otherwise be expected absent the negative social experience. Alternatively, perhaps performance would be comparable to that of relatively more aerobically fit participants. This would suggest that social exclusion effects are not universal, but rather exclusive to those with relatively lower aerobic fitness. Yet another alternative possibility is that a control arm shows a less robust practice effect. This would suggest that social exclusion in some way marshals cognitive resources that benefit performance on the more challenging cognitive task. Aerobic fitness possibly would dictate the degree to which these resources are optimized. Altogether, contextualizing the findings with a control arm would offer the opportunity to generate further ideas about how to proceed with next research steps in this area of inquiry.

Future social exclusion and cognitive performance research may also benefit from exploring how individuals regulate their feelings after being socially excluded. Changes in cognitive performance may be influenced by the type of regulation participants used. This may enhance understanding on the specific strategies children use to regulate the effects of social exclusion. Future research should consider a combination of having participants respond to open ended questions that assess different affect regulation strategies or manipulate regulation strategies in experimental designs (e.g., Sethi et al., 2013).

Additionally, we delimited the sample to female participants to remove sex as an additional between-subjects factor. Some research indicates that social exclusion is a more salient experience for female than male recipients (Beneson, Markovitz, Hultgren, Nyugen, Bullock, & Wrangham, 2013; Gunther Moor, Bos, Crone, & van der Molen, 2013). Future

research should consider potential sex effects on affect and working memory and the magnitude of these effects for different levels of aerobic fitness. Another concern related to the sample is that they reported high social competence as well as low loneliness in daily life. Highly socially competent children may be more resilient to a one-off event of social exclusion because it is inconsistent with their typical social interactions with peers. Future research should investigate if children with different levels of social competence respond differently to social exclusion.

Another limitation is that we examined one aspect of physical fitness. Physical fitness is a multidimensional construct comprising aerobic fitness, muscular endurance, muscular strength, flexibility, and body composition (Ortega, Ruiz, Castillo, & Sjostrom, 2008). This is an important consideration as research indicates that components of physical fitness other than aerobic fitness are associated with cognitive performance (Chu, Chen, Pontifex, Sun, & Chang, 2016; Kao et al., in press) and psychosocial well-being (LaVigne, Hoza, Smith, Shoulberg, & Bukowski, 2016). There is value in exploring other aspects of physical fitness beyond aerobic fitness in future developmental social exclusion research.

Lastly, findings may be valuable for children when they experience relationship difficulties because they may benefit from improving their physical fitness. However, the links among physical fitness, social relationships, and healthy functioning are dynamic and challenging to study. Children with poorer physical fitness may be more likely to face relationships difficulties like social exclusion (Janssen, Craig, Boyce, & Pickett, 2004) and relationships difficulties are a common reason why young people discontinue physical activity participation (Balish, McLaren, Rainham, & Blanchard, 2014). A greater understanding of the links among fitness, social relationships, and healthy functioning may benefit from future

research focused on how young people gain entry to participate in activities that improve their fitness and continue participation.

Strengths and Conclusion

Within the context of the limitations described above there remain several notable strengths of the present research. First, our results highlight that the effects of social exclusion may be dampened by aerobic fitness. Research exploring factors that can mitigate the potential negative effects of social exclusion are uncommon in the current literature base, especially for children. Aerobic fitness is a malleable construct that can be improved with sustained aerobic physical activity over time. Physical activity is also an accessible and low-cost way of improving aerobic fitness that children can accomplish in the course of their daily lives at school and in other activities. Second, we used a repeated measures design in this study to observe changes in affect and cognitive performance. This allowed for a richer understanding of how children change (i.e., shifts in affect, changes in cognition) rather than group differences that use a single time point. Lastly, social exclusion was manipulated in a controlled laboratory setting that allowed assessment of direct effects of social relationships, which offers an advantage over cross-sectional or correlational research. Considered together, this study enhances understanding of childhood social exclusion and provides a novel contribution to developmental psychology and exercise psychology literatures.

This research extends understanding of how aerobic fitness may benefit well-being, specifically showing that it holds potential to moderate the effects of social exclusion. Girls with higher aerobic fitness may be able to cope better after social exclusion than those with lower aerobic fitness. Importantly, aerobic fitness can be developed by participating in accessible exercise and sport activities. Though the findings reported here are preliminary and require

replication, they suggest value in pursuing future research that addresses performance changes over consecutive inclusion tasks, affect regulation, exploring other components of physical fitness, and other potential demographic and psychological moderators.

CHAPTER 4: GENERAL DISCUSSION

Social exclusion produces maladaptive functioning (Baumeister & Leary, 1995; Baumeister et al., 2007; MacDonald & Leary, 2005). Currently, there are few efficacious strategies to reduce the impact of social exclusion. This dissertation focused on how the transient effects of social exclusion might be mitigated with a short bout of physical activity in study one and by the personal characteristic of aerobic fitness in study two. Results showed that responses to exclusion may be mitigated through preservation of feeling states and self-regulation with preemptive walking and that aerobic fitness may enable more efficient regulation of emotion and cognition following exclusion.

One advantage of targeting the immediate effects of social exclusion is to understand in-the-moment responses that are important for daily functioning. How people feel and self-regulate are essential for well-being (Baumeister, Schmeichel, & Vohs, 2007). Focusing on immediate effects also offers a pathway to understand how transient responses may lead to chronic maladaptive outcomes. People who are more frequently socially excluded display poorer physical and mental health (Segrin & Passalacqua, 2010). This second advantage also has developmental implications for children as repeated exposure to social exclusion may compromise healthy psychosocial development (Brunstein Klomeck, et al., 2007; Robers, Kemp & Truman, 2013).

In study one, female college students who completed a brief 20-minute walk felt more pleasant after being socially excluded than students who were sedentary prior to being excluded. Additionally, higher perceptions of being ignored related to smaller changes in working memory performance only for participants who remained sedentary before being excluded. In study two, girls with higher levels of aerobic fitness demonstrated smaller declines in pleasant feelings as

well as larger increases in working memory performance compared to those with lower aerobic fitness. Collectively, the findings suggest that physical activity and aerobic fitness are promising for reducing the immediate effects of social exclusion and warrant continued investigation in future research.

Theoretical Contributions and Implications

Williams's (2007; 2009) temporal need threat model posits the effects of social exclusion follow a progressive sequence. The reflexive stage encompasses the immediate effects of social exclusion and is affective in nature. According to the belonging hypothesis, social exclusion is an aversive threat to well-being (Baumeister & Leary, 1995). Threats produce affective and cognitive responses that have strong evolutionary ties (Baumeister & Leary, 1995; MacDonald & Leary, 2005; Williams & Zadro, 2005). Hedonic affective responses are a core feature of threats and function to indicate the relative importance of events (Russel, 2003; Russel & Barret, 1999). This threat detection also activates the same neural circuitry in the brain for physical pain responses, suggesting that the experience of social exclusion is unpleasant and similar to physical pain (Eisenberger & Lieberman, 2004; Eisenberger, Lieberman, & Williams, 2003; Kross, Berman, Mischel, Smith, & Wagner, 2011).

Research suggests that social exclusion produces a shift away from current feelings towards a neutral state of affect (Blackhart et al., 2009). In study one, female college students reported a significant negative shift in pleasant affect from slightly-to-mildly pleasant towards neutral affect. In study two, adolescent girls reported a significant negative shift in pleasant affect from good to fairly-good towards neutral affect. The findings suggest social exclusion is an aversive threat to well-being. There are several conceptual perspectives that explain affective responses to social exclusion.

The numbing hypothesis posits the immediate affective response is an automatic termination of all affective processing (DeWall & Baumeister, 2006). This leads to impaired behavior regulation because without affective processing individuals are unable to effectively guide behavior. This hypothesis aligns with similar psychophysiological and somatic physical pain responses that lead to analgesic responses. A second perspective is the cognitive deconstruction hypothesis that posits social exclusion leads to a defensive psychological state where individuals withdraw from present feelings to avoid self-awareness (Twenge, Catenese, & Baumeister, 2003). By reporting reduced pleasant affect but not unpleasant affect, results may indicate that participants reported significant decreases in pleasant affect but refrained from reporting unpleasant affect as a defensive psychological strategy. A third conceptual perspective, related to the cognitive deconstruction hypothesis, is that individuals engage in both controlled and automatic affect regulation after being excluded.

This self-regulation occurs in the second stage of Williams's temporal need threat model, which is characterized by self-regulation strategies to cope, manage emotion, generate plans of action, and potentially execute behavior (Williams, 2007; Williams & Nida, 2011). Research suggests changes towards a neutral state of affect may result from affect suppression (Baumeister et al., 2002). People may wish to mask any unpleasantness to avoid immediate distress or hide feelings from others. Along with suppression, social exclusion leads to selective attention to pleasant compared to unpleasant affective stimuli, indicating that individuals may implicitly seek out positive stimuli as part of the coping process (DeWall et al., 2011). Controlled forms of affect regulation can place increased resource demands on the cognitive control systems that are responsible for self-regulation.

Neuroimaging evidence shows cognitive resources are prioritized towards affective processing and regulation during and following social exclusion (Chester & DeWall, 2014; Eisenberger et al., 2003; Kawamoto et al., 2013; Otten & Jonas, 2013; Themanson et al., 2013). These cognitive control systems are hypothesized to be quickly activated to attend to and regulate the affective responses to social exclusion. This rapid detection and regulation of social exclusion comes at a cost whereby cognitive resources are prioritized towards social exclusion and away from other salient tasks that require cognitive resources (e.g., behavior regulation, problem-solving). This dissertation specifically focused on the effects of social exclusion on working memory because working memory is important for daily functioning (Diamond, 2013) and is linked with academic performance throughout development (Bull et al., 2008; St Clair-Thompson & Gathercole, 2006). Furthermore, previous research has found participants who were social excluded showed lower working memory performance compared to those who were socially included among young adults (Buelow et al., 2015) and children (Hawes et al., 2012). Based on conceptual and empirical evidence, working memory is an ideal component of cognitive control to target in social exclusion research.

Results from study one and two partially support the idea that social exclusion impairs working memory. There was no direct evidence that social exclusion impaired cognitive control performance among female college-students and children. Social exclusion did not lead to performance decrements. However, this dissertation differs from the current literature base because measures of working memory were recorded prior to and immediately after social exclusion. A repeated-measures design allowed for analyzing individual change, which is advantageous for capturing how social exclusion progressively impacts individuals from reflexive to reflective stages of the temporal need threat model. Previous research has mostly

relied on between-subject group differences and post-hoc interpretations to explain the cognitive effects social exclusion (i.e., Baumeister et al., 2002; Hawes et al., 2012).

Results from study one indicated that all participants either maintained or improved working memory performance regardless of being socially excluded. The absence of negative effects of social exclusion may be attributable to the use of a college-aged student sample. College-aged students are regarded as high functioning and exposure to adverse social relationships throughout their schooling years may be likely. Such experiences may have led to a variety of efficiently functioning coping strategies in responding to social exclusion. These attributes of a college-aged sample may have been able to explain why impairments to working memory were not observed in study one. In study two, we applied a developmental lens by focusing on children. Their developing self-regulation skills may not be as efficient as those of college-aged students.

In study two, participants also improved their working memory performance following social exclusion, replicating findings with female college-students from study one. Together these findings suggest that laboratory manipulated social exclusion may not increase resource competition to the extent where working memory performance is impaired. While these findings do not necessarily contradict the conceptual argument that social exclusion can increase resource competition leading to impairments in working memory performance, they do highlight the challenges with manipulating social exclusion in a laboratory setting.

Manipulating artificial or new social relationships in a laboratory setting may not produce effects strong enough to impair working memory performance, despite the advantages of a controlled setting to observe direct or causal effects. Possibly the getting to know you and Cyberball paradigms produce small effects on perceived relational value. A likely occurrence is

that participants may not hold the artificial relationships with laboratory perpetrators of exclusion in high regard or perceive those relationships to be important. Perceived relational value is likely to be higher with actual preexisting relationships (i.e., best friend, teacher, coach, parent) than another person who participants were recently introduced to in a laboratory setting. If participants are not fully invested in establishing a relationship with others prior to social exclusion, then there is little room for participants to perceive those relationships to be devalued (i.e., floor effect). As a result, being excluded would not drastically impact the working memory performance of research participants because they did not perceive to be devalued from relationships that they already regarded as not important or of low value. This may explain why perceptions of being ignored and excluded did not cross the mid-point of the scale in study one. Also, this may explain why participants were able to quickly regulate the effects of social exclusion and improve their working memory performance relative to baseline performance.

Previous social exclusion research suggests that perceived relational value matters in a laboratory setting (Buckley, Winkel, & Leary, 2004). Indeed, Leary (2001) has argued that decreases in perceived relational value is the psychological mechanism responsible for social exclusion effects. Social exclusion is hypothesized to produce effects when devaluation occurs – perceiving a highly valued relationship to be devalued after social exclusion (Leary & Springer, 2001; Leary, Springer, Negel, Ansell, & Evans, 1998). There may be a certain threshold of devaluation that social exclusion triggers impairments in working memory performance. This threshold is likely to occur when there is a preexisting high relational value with the perpetrators of social exclusion. Measures of social exclusion perceptions may provide an index of devaluation. This might explain why higher perceptions of being ignored were related to smaller changes in working memory performance in study one.

When participants place low relational value on laboratory relationships prior to social exclusion, impairments to cognitive control may be observable through measures on a more sensitive level of analysis. Previous neurophysiological research has observed impairments to error monitoring performance (Themanson et al., 2014) and neural inhibition processes (Otten & Jonas, 2013). Other research has focused on activation of neural structures that are associated with cognitive control processes during social exclusion (e.g., Bolling et al., 2011; Sebastian et al., 2011). Among adolescents, negative peer relationships such as social exclusion are shown to activate affective and attentional networks in the brain that are involved in self-regulation (Pfeifer & Blackmore, 2012). These findings contribute to understanding of how social exclusion impacts neurophysiology.

Responses to physical activity can also be explained through physiological processes. The dual-mode theory proposes affective responses to physical activity (e.g., light-to-brisk walking) are typically pleasant and homogeneous across individuals at intensities that require aerobic metabolism (Ekkekakis, 2005; 2009; Ekkekakis et al., 2004). Previous research shows light aerobic physical activity to increase or maintain pleasant affect (Reed & Ones, 2009). Findings from study one are consistent with the dual-mode theory and in line with previous research. Thus, a short bout of walking prior to social exclusion may have utility in reducing the affective impact of social exclusion.

The cognitive-energetic model posits that physical activity arouses brain areas associated with cognitive control performance to meet task demands, thereby leading to improvements in cognitive performance (Audrissen, 2009; McMorris, 2008). This arousal may be important to assist affective and cognitive regulation during the reflective stage. Feelings of calmness and relaxation have been observed during the period following physical activity (Ekkekakis et al.,

2000), which may help dampen the affective impact of social exclusion. With a dampened affective response, individuals may be better able to regulate the effects of social exclusion. This is partially supported through an inverse association between perceptions of being ignored and working memory performance for participants that were sedentary prior to exclusion but not for those who walked prior to exclusion. This interpretation is consistent with the cognitive-energetic model (Audriffen, 2009; McMorris, 2008) such that walking may have enabled the allocation of cognitive resources to meet the demands of the working memory task following social exclusion, thereby leading to improvements in performance (Audriffen, 2009).

This dissertation also explored aerobic fitness. A growing body of research demonstrates a positive link between aerobic fitness and cognitive performance (Chaddock et al., 2011; 2012). Study two showed that participants with higher levels of aerobic fitness reported smaller decreases in pleasant affect and larger increases in working memory performance from inclusion to exclusion than participants with lower levels of fitness. The positive associations between aerobic fitness and changes in affect and working memory performance are consistent with existing literature (Drollette et al., 2016; Kao et al., in press; Hillman et al., 2005; Pontifex et al., 2011). Results from the 2-back task in study two also support the execute-control hypothesis that physical activity and fitness have their greatest benefits on cognitive processes that require the most effort (Colcombe & Kramer, 2003; Hall et al., 2001). Higher aerobically fit girls may be able to regulate the effects of social exclusion because of functional and structural differences associated with aerobic fitness (Chaddock et al., 2010; Chaddock-Heyman et al., 2014). Thus, lower aerobically fit girls may not show improvements of a similar magnitude to working memory performance because higher aerobic fitness may be tied to a more efficient self-regulation system.

Another possible explanation for why aerobic fitness moderated responses to social exclusion is that aerobic fitness is closely tied to an array of other adaptive psychological constructs and healthy behaviors. Therefore, individuals with higher aerobic fitness may also possess greater social and emotional functioning skills than those with lower aerobic fitness. Previous research has demonstrated that aerobic fitness is a powerful marker of health for young people (Ortega et al, 2008) and is tied to greater psychological well-being and academic achievement (Chu et al., 2016; Kao et al., in press). As aerobic fitness can be developed through increased participation in sustained aerobic physical activity, research has also demonstrated that physical activity participation is associated with improved social outcomes. Continued participation in physical activity can improve aerobic fitness as well as the development of various social skills that may serve to reduce occurrences of social exclusion. Indeed, participation in physical activity is positively associated with acceptance, popularity, social status and competence (Chase & Dummer, 1992; Chase & Machida, 2011; Evans & Roberts 1987; Ullrich-French, McDonough, & Smith, 2012; Weiss & Duncan, 1992). Therefore, individuals with higher levels of aerobic fitness may also possess greater social and psychological skills to assist in coping with social exclusion.

This dissertation used an interdisciplinary approach tying together theory from social and developmental psychology, exercise psychology, and affective and cognitive science. Findings support the idea that social exclusion presents a threat to the need to belong and has a strong impact on human functioning (Baumeister & Leary, 1995). Results also supported and extended the temporal need threat model by identifying aerobic fitness as a moderator of the reflexive and reflective effects of social exclusion. However, evidence for the impact of social exclusion on cognitive functioning was only partially supported in both studies. Findings are also consistent

with theories of physical activity and fitness that people derived pleasure from physical activity and effects are most pronounced for challenging cognitive functions. Therefore, this dissertation has made meaningful theoretical contributions to their respective literatures.

Limitations and Directions for Future Research

A limitation of this dissertation is that the artificial relationships manipulating in the lab may not accurately reflect social relationships outside of the lab. Although Baumeister and Leary (1995) contend that all people maintain a desire to be socially included by others, people possess a set of standards for how they value their relationships with others. This limitation may be able to explain improvements on working memory because participants may not have invested in forming a relationship with the perpetrators of exclusion. Observing impairments to working memory on the level of behavior is challenging for researchers because of ethical and practical challenges to manipulating social relationships in the laboratory. Only mild social exclusion can be explored in this context. Efforts to increase participants' efforts to invest in the artificial or new social relationships could strengthen effects. Some researchers have tried to incentivize efforts to be accepted (i.e., Buckley et al., 2004) which may be useful for future researchers to increase participant investment.

The getting to know you paradigm involves a group meeting that is designed to increase participant investment into those relationships, and Cyberball involves an imagery script that helps participants identify more strongly with the other virtual players. While these attempts were inherent to each paradigm, future research would benefit from making lab paradigms as meaningful as possible to participants. Researchers should be mindful that modifications to exclusion paradigms may introduce other psychosocial confounds. For example, using pictures in Cyberball may introduce cultural, racial, sex or other confounds. One noteworthy approach is

to give participants an actual or false opportunity to interact with the perpetrators of social exclusion after then are excluded. This may a way to elicit action planning by participants for subsequent interactions with the perpetrators of exclusion.

A limitation pertinent to most social exclusion research is if the documented effects are a result of a threat to the need to belong, a deprived sense of control, or both. Social exclusion comes in many forms that vary in their effects of an individual's sense of control. Some forms involve a total loss of control where efforts to regain a sense of control are difficult or impossible (i.e., abandonment, ostracism), whereas other forms that impact an individual's sense of control can be easily rectified such as contributing a relevant comment despite being ignored in group conversation. Distinguishing threats to the need to belong from a deprived sense of control are difficult because they are easily confounded in many forms of social exclusion. Future research may benefit from understanding to what degrees the need to belong and sense of control are threatened. Doing so could have implications for interventions that help individuals cope with issues related to belongingness or perceptions of control.

A third limitation of this dissertation is that measures of affect were limited to self-report. Subjective reports may be influenced by both experimental manipulations and defensive psychological strategies. Therefore, more comprehensive assessments of affective responses to social exclusion are needed in future research. A more comprehensive assessment of participants' affective responses could include physiological, expressive, or indirect measures. These measures may also be useful to directly assess ongoing self-regulation processes during the reflective stage of the temporal need threat model (Williams, 2007; 2009). Physiological measures of electromyographical (Kawamoto et al., 2013), electrodermal (Gross & Levenson, 1993), cardiovascular (Gunther Moor et al., 2013), or neurophysiological responses (Otten &

Jonas, 2013; Themanson et al., 2013) to stimuli are commonly used in affective science and can be implemented in social exclusion research. Though some of these measures may be difficult to implement while participants are physically active because increased movement. Additionally, other researchers have used indirect self-report measures of affect to understand implicit affective responses (DeWall et al., 2011). Future research may make best use of these tools as research questions focused on understanding affective responses to social exclusion and physical activity require and necessitate them.

This dissertation used a proactive approach to address the effects of social exclusion with preemptive walking in study one. One challenge for implementing such a proactive approach is that upcoming social exclusion must be predictable as with sport tryouts, auditions, or rushing a sorority or fraternity. However, social exclusion commonly occurs suddenly and unexpectedly. Future research may benefit from examining the effects of reactive walking, as research shows that engaging in a distracting task following social exclusion speeds up recovery from social exclusion (Wesselmann, et al., 2013). Despite the foreseeable benefits of walking after someone is excluded, reactive walking may not be an adaptive strategy because social exclusion has been shown to promote lethargic behavior (Twenge et al., 2003), predict reduced physical activity over time among adults (Hawkley et al., 2009), and decrease the amount of physical activity and increase the amount of sedentary behavior in young children (Barkley et al., 2012). Thus, reactive walking may detract from the overall quality of physical activity. Future research could benefit from examining the apparent cyclical benefits and detriments to reactive walking.

Another limitation is that study two did not manipulate aerobic fitness. Therefore, this dissertation was unable to assess if improving an individual's aerobic fitness to a level similar to those participants with higher aerobic fitness would afford similar protections against social

exclusion. Stronger experimental evidence could be obtained if aerobic fitness was manipulated through a structured physical activity program targeted at improving aerobic fitness. The role of aerobic fitness on responses to social exclusion could be evaluated at baseline and after the intervention to assess if improvements in aerobic fitness result in dampened responses to social exclusion. However, there are challenges with repeated exposure to laboratory manipulated social exclusion because paradigms involve deception and may produce expectancy effects. One paradigm that may be of interest is a peer-rejection task (Gunther Moor et al., 2013). This task involves participants making judgments of other similar aged peers' photos and receiving bogus feedback on whether peers accept or reject them. Unique to this task is that expectancy effects can be manipulated, which may be useful for intervention with multiple exposures to social exclusion.

A final limitation that warrants consideration for future research is that the exact factors used (i.e., walking and aerobic fitness) are from a much broader spectrum of healthy behaviors involving physical activity. For instance, physical activity can vary by type, intensity, and duration. Future research may benefit from exploring different types, intensities, and durations of physical activities that are practical and feasible for their target sample. Another related point is that aerobic fitness is one component of physical fitness. Physical fitness is comprised of aerobic fitness, muscular endurance, muscular strength, flexibility, and body composition (Ortega et al., 2008). There is much to be gained by exploring other aspects of physical activity and fitness in future social exclusion research.

Practical Implications

Activity based factors such as walking and aerobic fitness offer adaptive and healthy strategies for individuals to mitigate the impact of social exclusion. Proactive strategies that

reduce the effects of social exclusion are valuable because social exclusion often occurs unexpectedly and is difficult to predict. Specifically, walking is one of the most common and accessible physical activities that people can incorporate into their daily lives with little burden and cost. Physical activity is a unique strategy that differs from other psychological or behavioral strategies to address social exclusion because it offers a range of physical and mental health benefits beyond the primary goal of helping cope with social exclusion (Fox, 1999; Paluska & Schwenk, 2000; Penedo & Dahn, 2005). Another unique advantage to physical activity is that it can be used proactively and reactively. Proactive physical activity may be most useful when social exclusion can be predicted, as with scheduled cuts from a sports team, rushing a fraternity or sorority, or auditions. Reactive physical activity may be most useful for unexpected social exclusion. Using physical activity to avoid or distract from the effects of social exclusion may also offer new social opportunities, especially when physical activity is group based (e.g., dance, fitness classes, sport). However, future research will be needed to understand how social exclusion impacts the quality of physical activity behavior following an event of social exclusion.

When physical activities of moderate-to-vigorous intensity are sustained over time through, for example, running, jogging, or bicycling, activity related attributes such as aerobic fitness can be developed. Sport or physical education are contexts where moderate-to-vigorous activity can be regularly achieved. Additionally, sport and physical education are social contexts. There exists the potential for developing positive relationships with peers and competencies in several domains of functioning (Smith, 2003). Therefore, participating in structured physical activity may provide children a way to improve their aerobic fitness as well as competencies in emotional, physical, and social domains. The links between competence and adaptive outcomes

throughout development are well-established (Masten & Coatsworth, 1998). Contexts where individuals can develop their aerobic fitness and competencies may be especially important because they have the potential to fulfill unmet belongingness needs and can provide meaningful, satisfying social relationships that contribute to well-being when structured appropriately (Smith & Delli Paoli, in press; Verhagen, et al., in press).

Research that provides solutions to help people contribute to translational science. Physical activity and fitness are important to consider in developmental and performance contexts such as sport, school, or work. Individuals may be more likely to make use of the findings from this dissertation because behaviors and attributes of health are tangible and relatable. This highlights the novel contribution of this dissertation: exploring factors to reduce the effects of social exclusion.

Conclusion

Social exclusion is common in daily life and has adverse effects on healthy functioning. Because of these adverse effects, there is value in exploring behaviors and attributes that may assist in coping with exclusion. Current understanding of ways to reduce the impact of social exclusion is limited. This dissertation examined two complementary aspects of health to address the affective and cognitive responses to social exclusion – physical activity and aerobic fitness.

Findings from study one show that walking prior to social exclusion may mitigate the affective response to social exclusion as well as social perceptions that can undermine working memory. Furthermore, study two showed that higher levels of aerobic fitness may help girls cope with being socially excluded.

Collectively, these dissertation studies offer a novel and complementary approach to address the effects of social exclusion. Health behaviors such as physical activity are accessible

to a majority of people to incorporate into their daily lives with low burden and cost. Both physical activity behavior and aerobic fitness are associated with a range of positive physical and mental health outcomes. This dissertation used an interdisciplinary approach that provided a holistic and comprehensive understanding of the links among activity, fitness, social relationships, affect, and cognition. This approach is novel, offering a foundation for future research and practical strategies to reduce the adverse effects of social exclusion.

APPENDICES

APPENDIX A

Study One — Human Research Protection Program Approval Letter

MICHIGAN STATE UNIVERSITY

Initial IRB Application Approval

July 21, 2014

To: Alan Smith
IM Sports Circle
308 W. Circle Drive, Room 130

Re: IRB# 14-748 Category: EXPEDITED 6,7
Approval Date: July 21, 2014
Expiration Date: July 20, 2015

Title: Exercise and Teambuilding

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved.**

This approval includes a waiver of documented consent.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an *Application for Renewal* application at least one month before expiration. If the project is completed, please submit an *Application for Permanent Closure*.

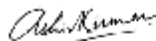
Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an *Application for Revision* to have your changes reviewed. If changes are made at the time of renewal, please include an *Application for Revision* with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,



Ashir Kumar, M.D.
BIRB Chair

c: Anthony Delli Paoli, Matthew Pontifex, Jordan Blazo, Olufemi Oluyodun



Office of Regulatory Affairs
Human Research
Protection Programs

Biomedical & Health
Institutional Review Board
(BIRB)

Community Research
Institutional Review Board
(CIRB)

Social Science
Behavioral/Education
Institutional Review Board
(SIRB)

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Fax: (517) 432-4503
Email: irb@msu.edu
www.humanresearch.msu.edu

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APPENDIX B

Study One — Empirical Valence Scale

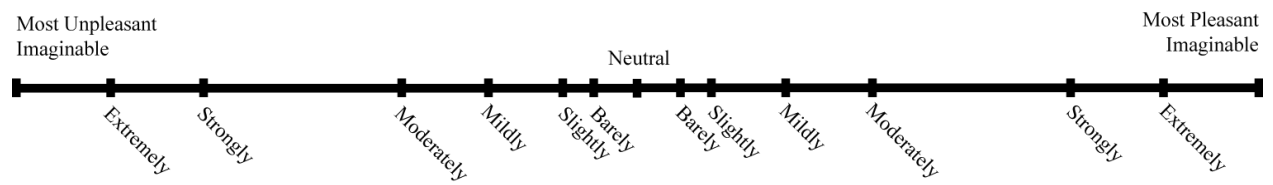


Figure 6. Empirical valence scale.

APPENDIX C

Study One — Manipulation Check

The following questions will ask you about your feelings about the partner task.
For each question, please circle the number to the right that best represents the feelings you were experiencing regarding the partner choices.

	Not at all				Extremely
1. I was ignored	1	2	3	4	5
2. I was excluded	1	2	3	4	5

APPENDIX D

Study Two — Human Research Protection Program Approval Letter

MICHIGAN STATE UNIVERSITY

Initial IRB Application Approval

June 14, 2016

To: Alan Smith
IM Sports Circle
308 W. Circle Drive, Room 130

Re: IRB# 16-550 Category: EXPEDITED 7
Approval Date: June 2, 2016
Expiration Date: June 1, 2017

Title: Physical, Imagination, and Computer Skills

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved.**

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

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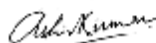
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Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,



Ashir Kumar, M.D.
BIRB Chair

c: Anthony Delli Paoli



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APPENDIX E

Study Two — Guardian Measures

1. What is your relation to the child?

☐ Mother ☐ Father ☐ Guardian ☐ Other _____

2. What is your child's date of birth? (MM/DD/YYYY) _____

3. What is your child's age in years? _____

4. What is your child's sex?

☐ Female ☐ Male

5. What is your child's ethnicity?

☐ Hispanic/Latino(a)
☐ Not Hispanic/Latino(a)
☐ Prefer not to say
☐ Do not know

6. What is your child's race?

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☐ White
☐ Mixed
☐ Other
☐ Prefer not to say
☐ Do not know

7. What is the highest level of education obtained by your child's?

Mother / Female Guardian

Father / Male Guardian

☐ Did not complete high school
☐ High school graduate
☐ Some college
☐ Associate's degree
☐ Bachelor's Degree
☐ Advanced or Terminal Degree
☐ Prefer not to say

☐ Did not complete high school
☐ High school graduate
☐ Some college
☐ Associate's degree
☐ Bachelor's Degree
☐ Advanced or Terminal Degree
☐ Prefer not to say

8. What is your approximate gross household income?

(Income includes wages and salaries, unemployment insurance, disability payments, child support payments received, as well as any personal business, investment, or other kinds of income received routinely.)

☐ Less than \$10,000
☐ \$10,000 to \$20,000
☐ \$20,000 to \$30,000
☐ \$30,000 to \$40,000
☐ \$40,000 to \$50,000
☐ \$50,000 to \$60,000
☐ \$60,000 to \$70,000
☐ \$70,000 to \$80,000
☐ \$80,000 to \$90,000
☐ \$90,000 to \$100,000
☐ More than \$100,000
☐ Prefer not to say

9. What is your child's dominant hand?

☐ Right

☐ Left

☐ No preference

10. Does your child wear contacts or glasses ☐ Yes ☐ No

11. How many siblings does your child have _____

12. What is your child's birth position (ex. 1st = oldest) _____

13. Is your child on free or reduced lunch at school? ☐ Yes ☐ No

14. What grade is your child currently in?

☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th

15. Please list the sport(s) your child currently participates in:

16. How often does your child participate in sports on a weekly basis? _____hr/wk

17. Please list the other activities your child currently participates in (ex. music, art, etc):

18. How often does your child participate in other activities on a weekly basis? _____hr/wk

19. On an average day during the WEEK, how much time does your child spend:

Watching television	_____ hours	or	☐ Not applicable
On the computer	_____ hours	or	☐ Not applicable
Playing videogames	_____ hours	or	☐ Not applicable
Being physically active	_____ hours	or	☐ Not applicable

20. On an average day during the WEEKEND, how much time does your child spend:

Watching television	_____ hours	or	☐ Not applicable
On the computer	_____ hours	or	☐ Not applicable
Playing videogames	_____ hours	or	☐ Not applicable
Being physically active	_____ hours	or	☐ Not applicable

21. How much sleep does/did your child get:

On an average week night	_____ hours
On an average weekend night	_____ hours
Last night	_____ hours

Circle the number that *best describes* your child's home behavior over the past 6 weeks

		Never or rarely	Sometimes	Often	Very Often
1.	Fails to give close attention to details or makes careless mistakes in schoolwork	0	1	2	3
2.	Fidgets with hands or feet or squirms in seat.	0	1	2	3
3.	Has difficulty sustaining attention in tasks or play activities.	0	1	2	3
4.	Leaves seat in classroom or in other situations in which remaining seated is expected.	0	1	2	3
5.	Does not seem to listen when spoken to directly.	0	1	2	3
6.	Runs about or climbs excessively in situations in which it is inappropriate.	0	1	2	3
7.	Does not follow through on instructions and fails to finish work	0	1	2	3
8.	Has difficulty playing or engaging in leisure activities quietly.	0	1	2	3
9.	Has difficulty organizing tasks and activities.	0	1	2	3
10.	Is "on the go" or acts as if "driven by a motor."	0	1	2	3
11.	Avoids tasks (e.g., schoolwork, homework) that require sustained mental effort.	0	1	2	3
12.	Talks excessively.	0	1	2	3
13.	Loses things necessary for tasks or activities.	0	1	2	3
14.	Blurts out answers before questions have been completed.	0	1	2	3
15.	Is easily distracted.	0	1	2	3
16.	Has difficulty awaiting turn.	0	1	2	3
17.	Is forgetful in daily activities.	0	1	2	3
18.	Interrupts or intrudes on others.	0	1	2	3

Tanner Staging Questionnaire

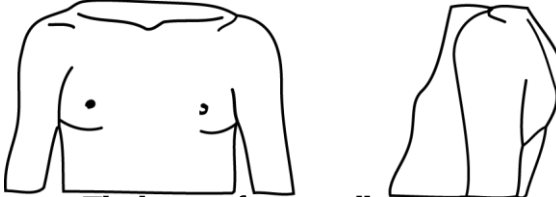
On each side of the line, please circle the number that *best represents* your child's pubertal status.

1.



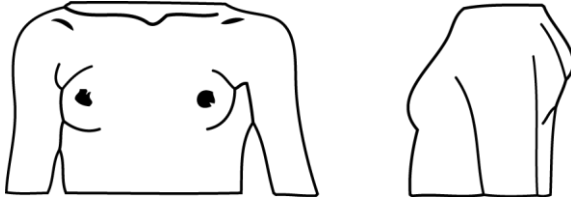
The breasts are flat.

2.



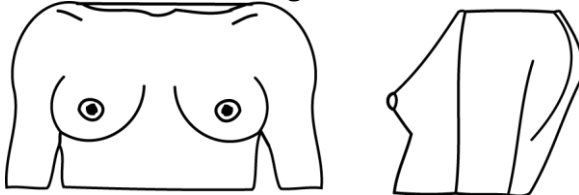
The breasts form small mounds.

3.



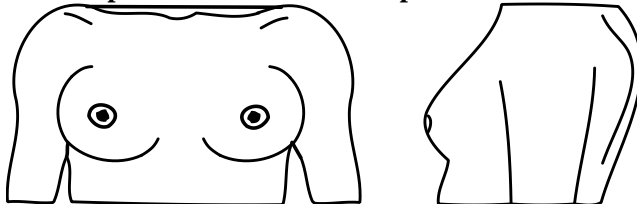
The breasts form larger mounds than in 2.

4.



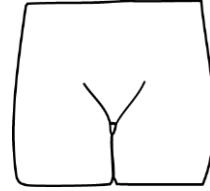
The nipple and the surrounding part (*the Areola*) make up a mound that sticks up above the breast.

5.



Only the nipple sticks out beyond the breast.

1.



No hairs.

2.



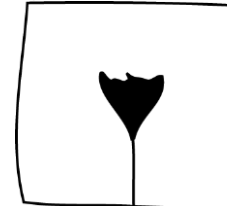
Very little hair.

3.



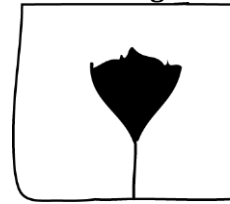
Quite a lot of hair.

4.



The hair has not spread over the thighs.

5.



The hair has spread over the thighs.

APPENDIX F

Study Two — Child Measures

Below are 24 statements. Please read each statement and indicate how true it is for you using the following rating scale:

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

Please circle your answer on the scale below each question.

1.	It's easy for me to make new friends at school.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
2.	I like to read.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
3.	I have nobody to talk to.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
4.	I'm good at working with other children.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
5.	I watch TV a lot.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
6.	It's hard for me to make friends.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
7.	I like school.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
8.	I have lots of friends.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
9.	I feel alone.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
10.	I can find a friend when I need one.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5
11.	I play sports a lot.				
	Always True 1	True most of the time 2	True sometimes 3	Hardly ever True 4	Not True at all 5

12. It's hard to get other kids to like me.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

13. I like science.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

14. I don't have anyone to play with.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

15. I like music.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

16. I get along with other kids.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

17. I feel left out of things.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

18. There's nobody I can go to when I need help.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

19. I like to paint and draw.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

20. I don't get along with other children.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

21. I'm lonely.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

22. I am well-liked by the kids in my class.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

23. I like playing board games a lot.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

24. I don't have any friends.

Always True	True most of the time	True sometimes	Hardly ever True	Not True at all
1	2	3	4	5

In general, others...

1....treat me as if I am invisible	Never 1	2	3	4	Always 5
2....look through me as if I do not exist	Never 1	2	3	4	Always 5
3....have ignored my greetings when we are walking by one another	Never 1	2	3	4	Always 5
4....ignore me during conversation	Never 1	2	3	4	Always 5
5....ignored me	Never 1	2	3	4	Always 5
6...."hang out" with me at my home	Never 1	2	3	4	Always 5
7....invite me to join their club, organization, or association	Never 1	2	3	4	Always 5
8....include me in their plans for the holidays	Never 1	2	3	4	Always 5
9....make an effort to get my attention	Never 1	2	3	4	Always 5
10....invite me to go out to eat with them	Never 1	2	3	4	Always 5
11....invite me to join them for weekend activities, hobbies, or events	Never 1	2	3	4	Always 5

Instructions:

- The following statements deal with what kind of a person you are
- Please read both statements in each row
- Decide which of the two statements is most like you (left statement vs. right statement).
- Once you pick a side, mark whether this is "REALLY TRUE FOR ME" OR "SORT OF TRUE FOR ME" by marking the appropriate box with an X.
- Please choose only ONE answer.
- Remember: *There are no right or wrong answers; simply choose the one that is best for you.*

What I Am Like

	Really True for me	Sort of True for me			Sort of True for me	Really True for me
Sample Sentence						
a.	☐	☐	Some kids would rather play outdoors in their spare time	BUT	Other kids would rather watch T.V.	☐ ☐
2	☐	☐	Some kids find it hard to make friends	BUT	Other kids find it pretty easy to make friends	☐ ☐
8	☐	☐	Some kids know how to make classmates like them	BUT	Other kids don't know how to make classmates like them	☐ ☐
14	☐	☐	Some kids don't have the social skills to make friends	BUT	Other kids do have the social skills to make friends	☐ ☐
20	☐	☐	Some kids understand how to get peers to accept them	BUT	Other kids don't understand how to get peers to accept them	☐ ☐
26	☐	☐	Some kids wish they knew how to make more friends	BUT	Other kids know how to make as many friends as they want	☐ ☐
32	☐	☐	Some kids know how to become popular	BUT	Other kids do not know how to become popular	☐ ☐

How do you feel right now? Circle a number.

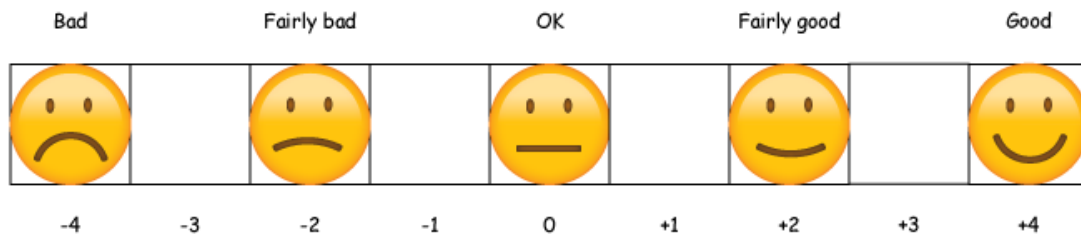


Figure 7. Children's feeling scale.

APPENDIX G

Study Two — Manipulation Check

For each question, please circle the number to the right that best represents the feelings you had during the ball toss game.

	Not at all				Very much so
1. I felt happy	1	2	3	4	5
2. I felt sad	1	2	3	4	5
3. I felt ignored	1	2	3	4	5

APPENDIX H

Study Two — Advertisement Flyer

Does your child want to participate in a research study?

We are doing a study to learn more about girls' physical fitness and cognitive performance.

Eligibility

- ✓ 9-12 years old girls
- ✓ Able to exercise

Those who qualify will be able to receive a \$15 gift card for participating in a two-hour session.

Please contact

Anthony at
(517)-353-6497
dellipao@msu.edu



Scan to email directly

SiMPL
Science & Motor Educational Processes
in Physical Activity Lab



Figure 8. Study two advertisement flyer.

REFERENCES

REFERENCES

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