THE INFLUENCE OF PHYSICAL ACTIVITY IN AN OUTDOOR SETTING ON MEMORY

Rebecca Curtis

Submitted in partial fulfillment of the requirements
for the degree
Master of Science
in the School of Public Health
Indiana University
March 2016

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the Requirements for the degree of Masters of Science

Thesis Committee

_____
Alan Ewert, Ph.D.

_____
William Ramos, Ph.D.

_____
Jonathon Beckmeyer, Ph.D.

Date of Defense: March 23, 2016

Acknowledgements

I would like to express my gratitude to my thesis committee, Dr. William Ramos and Dr. Jonathon Beckmeyer; with special thanks to committee chair, Dr. Alan Ewert, whose guidance and support throughout this process made this thesis possible.

I would also like to thank St. Peter's Lutheran School for their contribution to the project and willingness to participate in the study.

Finally, I would like to thank my family and friends whose support and encouragement help me in all I do.

Rebecca W. Curtis

THE INFLUNECE OF PHYSICAL ACTIVITY IN AN OUTDOOR SETTING ON MEMORY

This study explored the outcome setting of physical activity had on 2nd grade students' memory. Specific attention was given to given to the vestibular system, in charge of balance and equilibrium. In order to understand how setting affected memory, a maze with specific stations was set-up inside the school and in an outdoor space with a pre- and post-memory test given before and after the 6-week maze study. Coupled with the post-memory test was a 12 command review, testing both the indoor and outdoor group of students on the number of commands they were able to memorize and execute correctly. Overall physical activity done in different setting seemed to have little difference on student's memory; however, this study highlights inter-personal growth and higher command retention within students who participated in physical activity in the outdoor setting. In this way, outdoor physical activity may serve as a foundation for interpersonal outcomes within the school system.

Table of Contents

Chapter 1

Background

In child development children are observed understanding the world around them through exploration, generally labeled play (Henricks, 2014). Play is a state of being that one is engaged in during an enjoyable activity (Sattelmair & Ratey, 2009). It can be either physically active sports or sedentary video games. This paper is focusing on active play in the form of structured physical activity and how it influences memory.

Candace Meyer, designed a physical movement program called *Minds in Motion* to enhance the vestibular system (Meyer, 2012). The vestibular system is located within the inner ear and is responsible for balance, head motion and three-dimensional spatial orientation (Day & Fitzpatrick, 2005). To activate the vestibular system, Meyer developed a maze which includes balance beams, throwing and catching bean bags with specific hands, rolling straight down a mat, and eye tracking activities. These activities often require students to focus on crossing their midline, the invisible line splitting the body in half vertically, to increase the connection between the right and left sides of the brain (Meyer, 2010; Staley, 1980). Outcomes from these activities have resulted in students having higher reading scores, following auditory instructions better, and increasing balance and motor coordination (Griss, 1998; Meyer, 2010). Activities based off of the *Minds in Motion* program have been adapted into various school systems from 5-minute classroom breaks to 20-minute maze times focused on improving student's vestibular systems and raising academic success.

The author of this study became interested in this phenomenon because of a background in education and exercise science. As an outdoor educator, learning with the whole body was emphasized as students absorbed information through all five senses. Exploratory hikes and

collaborative activities like baking cookies in a solar oven allowed students to self-direct knowledge application. The traditional school system expected students to learn mainly through visual and auditory methods. Knowing the importance physical movement has on the health of the whole body, including the mind because of prior personal training experience, the author desired to incorporate purposeful movement into lessons.

Statement of the Problem

Although movement is expected to improve children's memory (Jensen, 2000; Ratey, 2008), prior research has not examined if the setting physical movement is associated with children's memory gains. Physical movement in stereotypical exercise areas (e.g. on a treadmill, in a gymnasium) has been shown to activate the hippocampus with disregard to the surrounding view (Coteman & Berchtold, 2002; Ratey, 2008). Yet, natural settings are stated to decrease stress and invoke involuntary attention, mental relaxation, and increased cognitive functioning (Kaplan & Kaplan, 1989; Ulrich, 1984). And despite the *Minds in Motion* curriculum being implemented into various school systems, it had not been intentionally coupled with an outdoor environment. This unknown contributes to a gap in the understanding of the value outdoor settings with natural elements has on memory and academic progression.

Purpose of the Study

The purpose of this study was to test if physical activity in an outdoor setting has a different effect on children's memory that physical activity in an indoor setting. The findings of this study were expected to further the understanding of the effects of incorporating outdoor settings into the school day. This study also expands the body of knowledge relative to physical education, recess, and extracurricular activities as forms of physical movement which may be enhanced in outdoor settings.

Significance of the Study

A 2010 report from the Center for Disease Control and Prevention (CDC) stated that physical activity was shown to increase academic performance (CDC, 2010). In conjunction with this report various studies have demonstrated the influence exercise has on the hippocampus, the area of the brain responsible for memory (Coteman & Berchtold, 2002). Another result of exercise observed within the brain of both rodents and humans was neurogenesis, growth and development of nervous tissue (Coteman & Berchtold, 2002; Van Praag, 2009). In another example, Coteman and Berchtold (2002) demonstrated that exercise reduced the extent of cognitive decline in aging adults, regardless of education levels and self-efficacy (Ratey, 2008). Applying these reports and results to academic settings, programs like *Minds in Motion* have been designed to incorporate physical movement into the school day to improve students' academic status.

This idea is slowly infiltrating into the classroom in which lessons have been redesigned with the brain in mind (Jensen, 2000). The midline of the body is an imaginary line drawn from the top of the head to the feet dividing the body into two halves; activities that cross the midline of the body enhances communication between the right and left hemispheres of the brain. Connecting the brain allows the right-side, controlling intuition and long term memory, and the left-side, managing linear-sequential thinking, to build a stronger corpus callosum or bridge of communication between the two halves (Jensen, 2000; Staley, 1980). Thus, simple exercises like toe touches with opposite arms and stretches can encourage midline crossing and easily incorporated into the classroom.

Movement during class time is significant because of the role it has on children's development (Meyer, 2010). Piaget and Vygotsky largely advocated the importance of play for

children as their way of conceptualizing the world around them (Nicolopoulou, 1993). Thus, play is seen to evolve from imitation to imaginary situations leading to advanced role playing ultimately leading to established sets of rules for games (Winseler, 2003; Bodrova, Germeroth, & Leong, 2013). Hence, with less play a decline in understanding and developmental stages began to be noted because of sedentary lifestyles.

In addition to a decline in play, physical education classes and recess periods have been cut in order to teach students the required testing material reinforcing sedentary actions during school times (Jensen, 2000; Ratey, 2008). Thus, education has become a regurgitation of information with negative connotations being formed around the idea of taking risk. Coupled with advances in technology, mandated federal standardized testing, and negative perceptions of risk associated with outdoor play elementary students do not regularly engage in outdoor environments or natural elements (Hunt, 2008). Yet, play in outdoor settings is where children are reported to learn judgment, small-group behaviors, social awareness, and communication (Knight, 2009; Paisley, Furman, Sibthorp, & Gookin, 2008). Brown (2009) addresses the issue of risk taking and play stating,

> All parents need to foster that internally driven, self-directed play that will allow children to become secure and self-confident on their own. There are risks to this sort of play, and the risks should be monitored and minimized. But trying to suppress free play or rigidly control kids… [is a] far greater risk to their future health, success, and happiness (p 108).

Therefore a healthy, outdoor environment keeps one physically, emotionally, and socially stable while also creating self-directed and guided learning moments (Knight, 2009). Because of this, outdoor settings and access to natural elements are being researched to see how social and

academic dynamics are affected. And the two main theories aiding in this research is psycho-evolutionary heory (Ulrich, 1984) and attention restoration rheory (Kaplan & Kaplan, 1989).

Psycho-evolutionary theory proposes that humans receive positive mental and physical affects from exposure to natural settings. The reconnection occurs because of the instinctive tie that humans have to the environment they originally came from (green spaces like savannahs) elicit positive emotions and behaviors. Expanding off this premise attention restoration theory established four components – extent, being away, compatibility, and fascination – which explain how nature positively affects not only feelings and attitudes but also restores mental fatigue (Kaplan & Kaplan, 1989). In addition, both attention restoration theory and psycho-evolutionary theory propose that positive mental affect towards an outdoor environment causes higher levels of physical relaxation leading to increased cognitive processing (Montes, 1996). Thus, this study proposes that coupling the mental restoration properties of outdoor environments with the increased cognitive functioning of physical movement will result in increased memory scores.

Hypothesis

This study will test the null hypotheses:

1. The memory score between the outdoor maze group and indoor maze group will not be significantly different ($p = 0.05$).
2. There will be no statistical difference in the ability to recall commands between the indoor and outdoor group.

Delimitations

This study is delimited to the following:

1. The study took place at a private, parochial school;
2. St. Peter's Lutheran School has implemented *Minds in Motion* maze periods into their school day for kindergarten through 4th grade classes. Declining to participate in the maze is not an option for students;
3. The study took place for six(6) weeks during comfortable weather conditions following the school's outdoor recess policy;
4. All guardians were aware their student participate in *Minds in Motion* mazes daily. Active parental consent forms informed guardians an outdoor setting was being added to the maze for 2nd grade students;
5. The *Minds in Motion* coordinator accepted the premise of the psycho-evolutionary theory promoting natural environments.

Limitations

The study had the following limitations:

1. Unknown factors may be present in a student's life hindering them from academic success which are not addressed through the *Minds in Motion* program;
2. The brain is a complex organ, with ongoing research to gain more understanding. Current advances in neuroscience increase understanding on brain development and this study claims to increase cognitive processing. However, some studies have found that physical activity has no positive effect on neurological diseases (Van Praag, 2009);
3. This study only took one class of 2nd graders outside, thus limiting its generalization to other populations;
4. The study took place in an outdoor, green space located next to St. Peter's School boarded by green grass with urban views and sounds present.

5. All 2nd grade students participated in physical activity mazes five days a week; the outdoor group only experienced the outdoor environment twice a week.

Assumptions

The study was based on the following assumptions:

1. Elevated heart rates during aerobic exercise is linked to higher cognitive functioning in the hippocampus, where memory is stored (Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014; Ratey, 2008);
2. Visual exposure to nature increases human health through quicker physical recovery (Ulrich, 1984);
3. Elementary students desire to play and enjoy being outside;
4. Time in natural settings allows the brain to rest, leading to an increase in cognitive concentration and attention (Kaplan & Kaplan, 1989);
5. The *Minds in Motion* program improves student's vestibular systems which increases cognitive functioning, like memory, needed to succeed in school (Griss, 1998);
6. Powerful body postures (e.g. walking with shoulders back; stomping feet) encouraged by *Minds in Motion* stations increases children's self-confidence increasing their ability to attempt more challenging academic work (Carne, Cuddy, & Yap, 2010)

Definition of Terms

The following terms and definitions will be used throughout the paper:

Attention-Restoration Theory – spending time in nature increases cognitive concentration through four components: being away (escape from daily routine), extent (large enough area exploration can occur), fascination (forceless attention), and compatibility (human/environment chemistry) (Kaplan & Kaplan, 1989);

Indoor Maze – maze room within the school set-up with activity stations theorized to improve the mind-body connection with variations made weekly;

Memory – the ability to store and recall information (Emilien, Durlach, Antoniadis, Van der Linden, & Maloteaux, 2004)

Minds in Motion – Fifteen minute segments of maze activities involving motor commands (e.g. right kick, clap, bend), hand-eye coordination (e.g. bean bag toss, walking backwards), and balance (e.g. stand on one foot and count to ten) to connect neural pathways between the brain and the body (Jensen, 2000; Meyer, 2010);

Outdoor Maze – activity stations based off of indoor maze elements using a mixture of natural and artificial props (i.e. children sit against a tree, roll on the grass, and jump through hula hoops);

Outdoor Setting – in this study, the outdoor setting consisted of a manicured lawn with trees next to the school in which Minds in Motion maze stations are located;

Play – physical movement occurring to explore and understand one's world in a pleasurable manner (Brown, 2009; Henricks, 2014);

Psycho-evolutionary Theory – aesthetically pleasing settings in nature where positive emotions are evoked which reduces stress with physical and mental benefits (Ulrich, 1984);

Vestibular System – earliest developed sensory system within the inner-ear responsible for balance and spatial awareness; also linked to learning (Jensen, 2000).

Chapter 2

The Influence of Nature

Biophilia states that an innate connection between humans and natural living systems exists which is why benefits of outdoor spaces have causes a resurgence in the interest of theories stating that natural settings may have restorative mental outcomes (Wilson, 1984). Attention restoration theory (Kaplan & Kaplan, 1989) expanded upon Csikszentmihalyi's (1976) theory of flow with the concept of hard and soft fascination (Nakamura & Csikszentmihalyi, 2002; Berman, Jonides, & Kaplan, 2008). Advanced technology and city settings demand directed attention with various stimuli fatiguing the brain and making it difficult for new tasks to be mastered. Kaplan & Kaplan believe that observing natural views (soft fascination) utilizes indirect attention and has the ability to relax the brain because little mental effort is needed. In addition, psycho-evolutionary theory states that natural settings have restorative properties with respect to cognitive functioning because the aesthetically pleasing environments invoke positive emotions (Ulrich, 1984). Thus, physical activities occurring in natural environments may offer improvements in memory and other cognitive functioning.

Attention Restoration Theory (ART)

The capacity for an urban area to provide a space in which a natural settings are free from urban distractions is difficult to create. Yet, this was the goal Fredrick Law Olmsted (1870) had for urban parks stating:

> The irritation and waste of the physical powers [city factories] which result from the same cause, doubtless indirectly affect and very seriously affect the mind and the moral strength. It is upon our opportunities of relief from it, therefore…to maintain a temperate, good-natured, and healthy state of mind (p 28).

And with this framework, Olmstead designed Central Park located in the heart of New York City. In the same way, ART hypothesizes the natural environment has a positive affect on mental health through four main principles: extent, compatibility, fascination, and being away (Kaplan & Kaplan, 1989; Kaplan, 1995).

These four principles stem from the base of Kaplan & Kaplan's (1989) initial belief that views of natural settings increase concentration. The *extent* (Kaplan & Kaplan, 1995) of the environment is the intricate ability to place oneself in the way of natural beauty and feel connected. Acknowledging that one is a part of a larger setting, with the visual aids of large geographical features within a natural setting, provides a sense of association with the environment. For this reason, an affirmative resonance or compatibility must occur between the person and the natural environment for restorative properties to occur (Kaplan & Kaplan, 1995; Ulrich et al., 1991). The attribute of *compatibility*, a decrease in stress through eliciting positive emotions with positive physiological changes, stems from the premise of Ulrich's (1984) psycho-evolutionary theory (Clayton, 2012; Kaplan & Kaplan, 1995; Ulrich, 1991). *Fascination* is the in-directed attention offered in natural settings (e.g. sunsets) in which one enjoys a view without concentration. This may be the most distinctive characteristic natural settings offer which allow the brain to rest and become more efficient that cannot be electronically replicated (Kaplan, 1995; Kaplan & Berman, 2010). Lastly, the component of *being away* (Kaplan & Kaplan, 1995) is the feeling of constructively straying from one's normal routine (Taylor, Kuo, & Sullivan, 2002). And with these four components of ART, which are easily captured in outdoor settings, restored mental functioning is theorized to occur.

Thus, recruited university students were intentionally given, brain-fatiguing directed attention tasks. The entire group was split into two sections after the task: The first walked

through the university arboretum while the second walked the metropolitan's downtown area. Upon returning to the original site, the entire group was again asked to perform another exhausting, attention concentrated task. Repeated trails of this methodology showed walking through the arboretum produced better scores on the second brain-fatiguing task than walking downtown, no significance was found based on the season chosen (Berman, Jonides, & Kaplan, 2008). Therefore, it is postulated that the natural setting of the university arboretum provided fascination, extent, and a sense of being-away. These three components are also present at St. Peter's outdoor space.

Nevertheless, compatibility is in question as it cannot be guaranteed within a natural setting. As previously stated, fascination may be the natural environment's most distinctive characteristic. Extent can be replicated outside of natural settings by showing an individual how they are connected to a community or play a crucial role within their social network; being-away simply occurs when one is taken away from their routine schedule. Yet, it has mainly been through qualitative self-reports in which a harmony with nature is identified and compatibility is assessed (Hattie, Marsh, Neill, & Richards, 1997). Therefore, it is hypothesized that if compatibility is present, the other three factors will be present as well. The psycho-evolutionary theory addresses the importance of compatibility to elicit mental benefits through the theory of evolution.

Psycho-evolutionary Theory (PET)

Restorative properties of natural settings, with respect to cognitive functioning, generally occur in aesthetically pleasing environments. A study recording recovery time of patients with window views of trees and grass opposed to a brick wall concluded that the patients with natural views recovered quicker with less medical complaints and negative nurses' notes (Ulrich, 1984).

The pleasure that natural settings produces a positive mental state leading to an overall relaxation of the body.

Aside from psychological relaxation, other benefits are stated to occur in natural settings because of a decrease in competing stimuli. Visual, tactile, and auditory stimulants are constantly filtered to concentrate during conversation, avoid unnecessary crowds, and ignore advertisements (Berman, Jonidas, & Kaplan, 2008). In order for the brain to concentrate on one stimuli, all others must be blocked out to obtain focus (Berto, 2005; Berman, Jonidas, & Kaplan, 2008; Hans, 2001). Thus, breaking from one's daily routine creates a mental break; however, it does not guarantee a decrease in mental filtering because of an introduction of new stimuli. According to the evolutionary theory, when humans return to a natural habitat they once inhabited (e.g. savannah, rive), an unlearned predisposition for positive responses occurs causing a feeling of physical and mental well-being (Ulrich, Simons, Losito, Fiotito, Miles, & Zelson, 1991). However, if anxiety or fear are elicited within the natural setting, mental restoration will not occur. For this reason, the importance of a positive physiological and psychological connection to the environment is necessary for measured improvements.

As stated before, positive experiences with nature have generally been reported through qualitative reflections (Hattie, Marsh, Neill, & Richards, 1997). However, researchers in the Netherlands began studying the effect scenes of natural elements have on aggression and violence rates. Their findings showed that lower crime rates were calculated when natural views were present and feelings of neighborhood safety also increased (Grienewegen, van den Berg, de Vries, Verheij, 2006). Thus, it is inversely hypothesized that communities with greater access to natural settings have an increased well-being, both physically and mentally, and have positive emotions towards natural settings (Grienewegen, van den Berg, de Vries, Verheij, 2006; Ulrich

et al., 1991). Thus, the idea that natural settings elicit positive emotions leading to improved cognitive functioning is assessed by typical testing, self-reports, and outside statistics.

Physically Active Play

The CDC released a 2010 report on the positive impacts physical activity has on academics. Active participation in recess, physical education classes, classroom-based movement, and extracurricular activities positively correlated to increases in cognitive functioning (CDC, 2010). Academic benefits, like increased memory, were added as another positive outcome of physical activity in addition to the physiological benefits, like cardiovascular health and bone development (Burdette & Whitaker, 2005; CDC, 2010).

In addition, mental health improvements of mood and self-confidence were also reported after exercise with decreases in stress (CDC, 2010; Salmon, 2001; Van Praag, 2009). Thus, "brain breaks" have become popular ways to get students moving for five minutes in the classroom or twenty minutes during an obstacle course (Meyer, 2012; Ratey, 2008). Thus, as movement is incorporated, a positive correlation between exercise and increased academic achievements is motivating schools, such as Naperville Central High School and Titusville Area School District (Ratey, 2008), to begin implementing physical movement as an academic intervention.

Because of few studies looking at how physical activity affects children's developing brains, animals have primarily been used to understand the link between physical activity and cognitive development. Observations and studies show that through active play, primates learn vital survival skills such as communication and social standards (Brown, 2009; Graham & Burghardt, 2010).

Nevertheless, play has been studied by developmental psychologists in an attempt to understand human maturity since the early 1950s. For this reason, play has been categorized into

advanced cognitive stages and thought o express children's internal emotions (Hendricks, 2014). Vygotsky advocated that play and development were inseparable, with social play enhancing cognitive activity (Bjorklund & Brown, 1998; Henricks, 2014). And in order to allow children to actively play, an open space is needed.

Gymnasiums and cafeterias are utilized within the school days; however, outdoor fields and playgrounds allow children more organic exploration. Rocks and sticks provide sensory-motor interpretations while made-up games engage children's imaginations and current knowledge (Anggard, 2011; Francis, 2010; Martin, Eisenbud, & Rose, 1995; Spencer, 2004). In addition, outdoor settings add an element of tangible learning that utilizes the five senses and add meaning to abstract concepts (Clements, 2004; Graham & Burghardt, 2010). Picked flowers begin to wilt because they are dying or a stick may float down a stream because of the wind or current. Thus, questions are asked and answered through natural consequences being observed and children engaging in self-directed learning (Anggard, 2011; Staley, 1979). This process connects two familiar elements (e.g. rain and earthworms) for greater academic skills (Hill, Goldenberg, & Freidt, 2009; Paisley, Furman, Sibthorp, & Gookin, 2008). Therefore, physically active play develops a child's cognitive skills.

Movement's Effect on the Brain

The prefrontal cortex houses the hippocampus, the memory section of the brain and, as stated, grey matter connections in that area increase during adolescence. Researchers began scanning the human brain after exercise and discovered brain-derived neurotrophic factor (BDNF), an essential building block connecting the white and gray matter synapse connections within the hippocampal area (Corbin & Marquer, 2013; Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014, Cotman & Berchtold, 2002; Voss, Prakash, Erickson, Basak, Chaddock, Kim,

Alves, Heo, Szabo, White, Wojcicki, Mailey, Gothe, Olson, McAuley, & Kramer, 2010). Learning more about BDNF, it has become known as "Miracle-Gro for the brain" in charge of learning, memory, and emotion and also supports increased production of other glutamate receptors in the hippocampus due to vasodilation which occurs during physical activity (Cotman & Berchtold, 2002; Cotman, Berchtold, & Christie, 2007; Ratey, 2008, p. 40). As more blood is pumping through the brain, the production of BDNF occurs leading to an increase in hippocampal grey matter (Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014; Ruscheweyh, Willemer, Krüger, Duning, Warnecke, Sommer, Volker, Mooren, Knecht, & Flöel, 2011; Voss, Erickson, Prakash, Chaddock, Kim, Alves, Szabo, White, Wójcicki, Mailey, Olson, Gothe, Potter, Martin, Pence, Cook, Woods, McAuley, & Kramer, 2013). This observation led to the premise that BDNF is the bridge between increased memory and physical movement.

Merging Vygotksy's theory that cognitive development occurs during play with the science of increased BDNF production during physical activity, Voss et al. (2010; 2013) took older adults and placed them in two groups, participation in aerobic exercise and no exercise, for twelve months. Pre and post brain MRIs were taken with results showing adults who participated in physical movement had increased levels of BDNF (Voss, et al., 2013). The positive outcomes in older adults allowed more studies to begin targeting younger populations.

High schoolers were part of the younger population studied for the effects of physical activity on cognitive functioning. A suburban Chicago high school implemented an intervention, "zero hour PE" to aid students struggling in reading with a physically active class prior to the start of the school day. At the end of the year, freshman who had participated in the intervention improved their reading scores seven percent more than the Illinois state average (Jensen, 1998; Ratey, 2008). Because of this significance in academic increase, learning readiness physical

education classes were designed with a focus on movement that encompassed student's social, mental, and physical health (Ratey, 2008; Reilly, Buskist, & Gross, 2012). Therefore, the concept of incorporating movement within the school day to increase cognitive functioning due to neurogenesis has become a focus by both educators and neuro-scientists.

Summary

This literature review demonstrates the strong connection between physical activity and brain development, which ultimately increases memory. Vasodilation during exercise causes the production of BDNF within the brain leading to this retention of memory. Currently physical education classes are validating their need within the academic setting through improved academic reading scores gained by students participating in the mile run daily. Thus, the reintroduction of physical movement into school systems through various programs like *Minds in Motion* are in the beginning stages of significant academic results. This study helps to provide St. Peter's educators with results.

The literature review also provides a context explaining how psycho-evolutionary theory (Ulrich, 1984) in conjunction with the attention restoration theory (Kaplan & Kaplan, 1989) emphasize how outdoor settings refresh the brain in order for it to retain more knowledge. The brain needs both rest and exercise which can occur outside through the components of ART along with the positive natural chemistry introduced through PET. Simultaneous educational physical movement outside, within view of natural elements is an area that needs to be studied to see if mental health significantly increases. Therefore, the goal of this study is to demonstrate how structured physical activity in an outdoor setting effects cognitive functioning, with a focus on memory.

Chapter 3

Methods

The focus of this study is to examine memory changes after a minimum of four weeks in an outdoor, purposefully active, program during the child's school day. To describe the methods used in this study, the following sections are included in this chapter:

1. Study setup
2. Selection of instruments;
2. Selection of subjects;
3. Administration of survey instruments; and
4. Treatment of data.

In order to provide an in-depth understanding of what transpires during a Minds in Motion session, this current study utilizes a multiple-method design employing a memory test and participant observation. Data collection took place at St. Peter's Lutheran School in downtown Columbus, Indiana. As an alumni of the Lutheran school system, the researcher is familiar with the school's culture and staff.

Study Setup

To control for variability in the administration of the test, the researcher and Minds in Motion coordinator collaborated on the most unobtrusive methods to introduce and administer the pre and post-test to students congruent with their regular schedule. At this meeting the researcher explained the hypothesized benefits of natural settings and addressed major themes congruent with outdoor education. After this meeting, the details will be passed onto 2nd grade teachers via email to ensure understanding of study, design, goals, and other details. In addition to the detailed email, the researcher will conduct an in-person meeting to answer questions. The steps in this study began with a pre-memory test for both classes. One class completed the

outdoor maze for six weeks and learned 14 new commands while a second class completed the same maze indoors. After the six weeks, all students completed the post-memory test and a tallied score of observed commands done correctly for both groups.

Selection of the Instruments

Quantitative Instrument

The *Minds in Motion* program provided an auditory digit span assessment (see Appendix A) based off Sternberg's paradigm (Sternberg, 1966), which was originally designed as a short term working memory assessment in which participants attempt to recall a series of items with the aid of a probe. Scores were calculated based on reaction time (Donkin & Nosofsky, 2012). Despite the difficulty of measuring intellect and cognitive functioning, the Sternberg paradigm has been validated within the fields of psychology and neuro-science with a significant memory retention correlation of 0.17 (Neubauer, Riemann, Mayer, & Angleitner, 1997; Pelosi, Hayward, & Blumhardt, 1995). The *Minds in Motion* test was read to three to five students at a time, with five-second intervals between number sequences; the researcher's voice served as the probe while students were tasked with writing down as many sequences as possible (Monsell, 1978). This test was given to gauge the student's base working memory before the outdoor maze was introduced and upon the completion of the 6-weeks of the outdoor maze.

Commands (see Appendix B) are phrases acted out with a direct correlation of name to action (e.g. bend means bending forward to touch one's toes). The goal was for students to memorize 14 commands throughout the six week study showing memory gains the ability to correctly follow directions. Students were initially observed preforming commands within a group setting. Educational studies utilize observation to discern what a class finds significant, gage student's emotions, and recognize social dynamics (Kawulich, 2005). For young children,

structured physical activity in group settings allows them to follow peers and memorize information at their own pace, without the pressure of trying to remember for a test (Becker & Geer, 1957; Mays & Pope, 1995**).** During the post-memory test, students were individually asked to execute the commands learned during the 6-week study to determine if setting effected the amount of memorization occurring.

Selection of the Subjects

The subjects were recruited from the two 2nd grade classes at St. Peter's Lutheran School during the 2015-2016 school year. Consent to participate in the research project was obtained from student's guardians through an active, written consent form sent home in student's "take home" folders and returned to the school. Approval from the Indiana University Institutional Review Board was obtained before the study took place. The school randomly assigned one 2nd grade class to participate in the outside maze twice a week while the other class maintained their indoor maze schedule. Upon the termination of the study, the indoor maze will continue running for both 2nd grade classes for the rest of the school year. Incentives for guardians to allow child participation in the study included the possibility of increased executive functioning and control leading to increases in memory, dexterity, and interpersonal skills among their child. St. Peter's educators expressed interest in verification of the internal, empirical data that would support their stated reasons for integrating *Minds in Motion* into their curriculum. Students opted to participate because of the opportunity to play outside with the total estimated sample size of N=45(outside = 23; inside = 22).

Administration of the Instrument

Based off the Sternberg Paradigm (Sternberg, 1966), a Minds in Motion memory test was used to assess a base-line average of each student's short-term memory. Second graders in both

the indoor and outdoor maze groups were tested through the classroom pull out method. Their task was to write numbers in the exact order in which they are stated starting with a column of 10 two-digit numbers with the possibility of advancing to the column of seven-digit sequences (Doman, 1986; Meyer, 2010). Numbers were not repeated and talking was prohibited to ensure the researcher's voice was the only input short-term memory could recall (Sternberg, 1966). Once all students finished, a memory score was calculated with each number worth a tenth of a point. If students recorded a whole column of ten sequences correct they received a whole digit number with additional tenths of a point added for each correct sequence. For example, if a student wrote all 10 two-digit number sequences down correctly and four three-digit sequences, the score was 2.4 with a total possibility of seven (see Appendix C). Scores were recorded manually and transferred to an SPSS spreadsheet. Students were number coded to maintain privacy.

Two new commands were demonstrated each week for students to model throughout the following weeks. Students were expected to memorize these commands as they actively repeated them each week in addition to two new commands. To ensure students were learning correct directions, right and left "kicks" and "punches" were corrected by either the researcher or 2nd grade teacher. At the end of the six weeks, after students finished their memory test, they were asked to demonstrate each command as it was stated by the researcher. The number correct was tallied with a score recorded on the student's number coded paper to maintain privacy.

Treatment of the Data

To compare setting on memory between the indoor and outdoor maze groups as well as before and after an experiment, an analysis of covariance (ANCOVA) was conducted with the pre-test as the covariate, setting as the independent variable, and memory as the dependent variable. The

significance level was set at 0.05 which serves as the cutoff score for significance (Cohen, 1988). 0.05 is the common score associated with social science to indicate how much error is willing to be accepted. The probability of making a type 1 error, or false positive result, will occur five out of 100 times which is standard practice for behavioral science statistics (Henderson, 2006). Commands given to both the indoor and outdoor groups were analyzed through an independent samples *t*-test. The indoor group was exposed to more rote repetition memorization of commands, while the outdoor setting lent itself to memorization through group interactions. Table 1 shows the hypothesized effects that setting will have on student's memory, with both the indoor and outdoor groups resulting in similar memory gains.

The pre-test was used as the covariate to control for setting and student's ending memory. Students various levels of memory could affect the post-test, therefore the pre-test covariate removed a possible confounding variable. After six weeks of both 2nd grade classes participating in the maze, both groups took the post-test memory test. Both groups should have an increase in memory in which changes will be measured to see if the outdoor group's memory significantly changed due to the outdoor setting. Commands were recorded through tallied scores.

Table 1*: Setting's effect on memory.*

	QUANITATIVE Sternberg Paradigm	**QUANITATIVE Observation**
Indoor Setting	Pre: base-line memory average Post: increase due to physical activity	Able to do all 14 commands
Outdoor Setting	Pre: base-line memory average Post: increase due to physical activity	Able to do all 14 commands

Summary

Results from this study are useful for understanding what role outdoor physical activity plays in improving memory. Increased blood flow to student's brains during exercise aids in the production of brain-derived neurotrophic factor (BDNF), which increases hippocampal functioning through neurogenesis. Students begin to physiologically relax as positive emotions decrease stress and experience a feeling of escape from the daily school routine. These methods may show that movement in an outdoor setting can easily be incorporated into the school day within any school system.

Chapter 4

Introduction

This chapter outlines the findings from the procedures described in Chapter 3. The research question guiding this inquiry examines whether the setting, indoors or outside, with physical activity has an influence on memory. The study has one dependent variable and was analyzed using the analysis of covariance (ANCOVA) and independent *t*-tests to examine if memory changes occurred among the research subjects. For this study, the *Minds in Motion* physical activity curriculum, which is designed to stimulate the vestibular system, was implemented in both indoor and outdoor settings and served as the independent variable.

The following chapter is divided based on the two quantitative analysis: an independent *t*-tests for the 14 observed commands and an ANCOVA for the pre and post memory tests. These data were collected during the 2015-2016 school year from current 2nd grade students enrolled in St. Peter's Lutheran School participating in the *Minds in Motion* curriculum. The Indiana University Internal Review Board and Programs Involving Children policy approval was obtained along with active parental consent forms in order for students to partake in this study.

Results

Although 46 students (N=46: N outside= 24, N inside = 22) were eligible to participate at the beginning of the study, a smaller sample size was obtained. One parental consent form was never returned, one student joined the school's 2nd grade class during the middle of the study, one student missed multiple weeks of school due to a family emergency, and two students received doctor's notes stating ear conditions which excluded them from the *Minds in Motion* curriculum completely causing their data to be excluded from the study. Due to these reasons the number of usable samples was 41 students (N = 41). The study consisted of 25 male and 16 female 2nd grade students between the ages of 7 and 8 years old with a mean age of 7.5. The

sample size varies for each specific instrument due to a writing issue. One student wrote the numbered sequences in the same box, causing numbers to be written on top of each other and indecipherable. Another student wrote random numbers on the corners of boxes and it was unclear if it was done to help remember the sequence or for entertainment during the intervals between number sequences. Therefore, those two subjects pre and post memory scores were excluded from the ANCOVA analysis but their tallied command score was included.

Quantitative Analysis: Independent *t*-test

Tallied commands were analyzed using an independent *t*-test to measure change in memory. Commands were verbally stated at the end of each maze time with the goal for students to execute correct movements. Throughout the 6-week study, 14 commands were introduced and stated to 2nd graders in both inside and outside mazes; these same 14 commands were stated once students had completed their post-test with correct execution being recorded. To determine the magnitude of the treatment an effect size score was obtained for each independent sample *t*-test. The effect size is the magnitude of a treatment effect, independent of sample size. While the statistical analysis determines whether statistical differences between the indoor and outdoor groups exist in the population, the effect size indicates the importance of these differences. Cohen's *d* was used as the measure of effect size for each *t*-test result. Cohen's *d* was calculated using the formula $(M_2\text{-}M_1) / SD_{pooled}$ where the mean difference between the two groups is divided by the pooled standard deviation (Cohen, 1988). These guidelines suggest the following for the interpretation of effect sizes as small: $d = 0.2$, medium: $d = 0.5$, and large: $d = 0.8$, with positive results indicating improvement (Pallant, 2010). The null hypothesis of equal variances is retained based on Levene's test for the equality of variances ($p = .233$) at an alpha level of 0.05 (Levene, 1960). The Cohen's *d* statistic indicated a large effect size of +2.814, the students

outside performed commands 2.8 standard deviations better than the inside students. A total of 40 (N=40; n_{inside} = 18, $n_{outside}$ = 22) tallied command observations were included in this independent *t*-test as shown in Table 2. There was significant difference between the inside and outside setting group: The t value was t (38) = 8.67, p = .00. An arbitrary score of 0 was given to each student prior to the study with an ending mean score for the inside group (13.59) and the outside group (11.78) while both had similar standard deviations (0.647 and 0.667 respectively).

Table 2
Statistical findings of command retention between indoor and outdoor groups

	N	M	SD	*t*-score	*p*	Cohen's *d*
Inside	18	11.78	.647			
Outside	22	13.59	.667	8.67	< .00	2.814

Independent *t*-test Summary

The quantitative information gathered from the tallied command observations produced statistically significant results. These results supported the hypothesis proposed by the author that setting does have an effect on memory.

Quantitative Analysis: ANCOVA

ANCOVA was used to measure change in memory within subjects based on the setting in which physical movement took place. Using this statistical analysis allowed the confounding variable of initial memory to be statistically controlled by using pre-memory scores as the covariate. Post-memory scores were the dependent variable with the indoor and outdoor groups as levels of the independent variable. Independence of observations was ensured through the use of two school pre-assigned 2nd grade classes that also meet the independent group assumptions for one class going outside and one staying inside for their physical movement. The null

hypothesis of equal variances is retained based on Levene's test for the homogeneity of variances (p = .952) at an alpha level of 0.05 (Levene, 1960).

To determine the magnitude of the treatment an effect size score was obtained. Eta squared scores were used as the measure of effect size for the ANCOVA result. Eta squared was calculated with the formula: $\eta^2 = SS_{effect} / (SS_{effect} + SS_{error})$ where eta squared equals the treatment sum of squares divided by the total sum of squares. Guidelines outlined by Cohen (1988) for interpretation of eta squared effect sizes follow the general rule that small = 0.01, medium = 0.06, and large = 0.138 (Pallant, 2010).

The independent variable of setting was compared with the dependent variable of memory. Table 3 shows the descriptive statistics with a total of 38 (N=38; n_{inside} = 18, $n_{outside}$ = 20) pre and post-test scores; mean and standard deviations for both groups are also included. The total mean for pre and post memory tests (3.8) showed little variation between the inside and outside groups (3.794 and 3.955 respectively) as both groups performed about +1 standard deviations (0.926 and 1.022 respectively). Table 4 shows the ANCOVA results of the pre and post memory test scores. There was no significant difference between the inside and outside setting of physical activity on memory: F = 0.237, p = .629, partial eta squared = .007.

Table 3

Descriptive statistics for memory changes in indoor and outdoor settings for student's participating in physical activity

	Memory		
Setting of Physical Activity	N	M	SD
Inside	18	3.794	.926
Outside	20	3.955	1.022
Total	38	3.878	.968

Table 4

Statistical findings of pre and post-test scores between indoor and outdoor groups

Source	SS	df	MS	F Ratio
Covariate (pre-test)	.243	1	.243	.249
Between	.232	1	.232	.237
Within	34.196	35	.977	
Total	34.683	37		

ANCOVA Summary

The quantitative ANCOVA analysis produced no statistically significant results and the null hypothesis failed to be rejected. Upon examination of within group scores (SS_{within} = 34.196), a nuisance variable seems to be present as the use of intact school classes cause nonequivalent grouping and a lack of true randomized design. Taking this limitation into account, the quantitative ANCOVA data gathered can still provide insight into the influence of physical activity for consideration for future studies discussed in the following chapter.

Summary

The two hypotheses tested in this study were:

1. The memory score between the outdoor maze group and indoor maze group will not be significantly different ($p = 0.05$).

The null hypothesis failed to be rejected ($p = .629$)

2. There will be no statistical difference in the ability to recall commands between the indoor and outdoor group.

The null hypothesis was rejected ($p = .00$).

These two analyses show that the outdoor setting has an effect on memory; however, the extent was not able to be determined at this time. Yet, this study leads to the assumption that physical activity, regardless of setting, increases memory ($p = .297$) as cited in the 2010 CDC report (CDC, 2010).

Results Summary

The total number of students who participated in the study was N=41 and a large quantity of data was able to be collected. From these data, conclusions were drawn regarding the changes in memory that occur in students who participate in indoor verses outdoor physical activity. The data suggest that the setting of physical activity has no statistical significance on memory on pre and post memory scores; however, the memory of the outdoor group did have statistically significant higher command memory retention. Thus, these statistical conclusions lead to further discussion and research on the effect outdoor setting has on elementary students' memory.

Chapter 5

Summary Discussion

This study investigated how the setting of physical movement influenced memory. The subjects in this study (N = 46) participated in a six-week *Minds in Motion* maze in an indoor and outdoor setting. They completed two quantitative tests: a pre and post memory test and an observed recall of 14 commands to gather data about the changes experienced in memory of 2nd grade students attending St. Peter's Lutheran School.

The information gained in this study can be used to examine how the setting in which physical activity occurs effects memory for verbal items, like the commands. In addition to this, it can also be used to understand how memory is improved and the importance of incorporating a combination of physical activity and natural settings.

Findings

The analysis of covariance (ANCOVA) controlled pre-test scores so that differences in pre-test score variables did not affect post-test memory scores; the independent t-test analysis compared the means of the two independent indoor and outdoor groups command recall. Results demonstrate that participating in the *Minds in Motion* program outdoors, compared to indoors, was related to remembering more commands.

Discussion and Implications

The findings conclude that physical activity, regardless of setting, increases memory. Commands were taught and practiced multiple times throughout the six-week study, while the pre and post memory test was given only twice to see how well students could recall number sequences based on the setting in which they had done physical activity. The difference in how the commands were learned and the test was given were not originally accounted for as a

confounding variable on how much students remembered. Thus, the current study only focused on memory between physically active groups placed inside and outside. Although positive results for the outside groups' memory of commands was found, the pre and post memory test was not significantly different. These results, therefore, suggest that the outdoor setting may not have had as robust of an impact as suggested through the theories of ART and PET.

Nevertheless, the outdoor setting may provide insight into how interpersonal dynamics may be enhanced during outdoor activities in a more indirect way. Interpersonal skills are important for academic success because the majority of academia is done in group settings. Ensuring that all students understand directions and learning to resolve conflict are taught in the moment in outdoor settings because isolating students to the hallway is not easily done.

Thus, the findings of this study yield many implications for researchers and practitioners. The implications of this study show that the intervention of physical activity during the school day is beneficial for student memory. Post-memory test scores for both indoor and outdoor moving groups showed memory increases regardless of setting. However, the fact that the memory recall of the outdoor group was significantly higher than the indoor group's score implies that the outdoor setting had a factor that enhanced memory. In addition to this, the study provides a new foundation for thinking about the types of educational outcomes elementary students experience while participating in physical activity and in outdoor settings.

Personal Observations

During the six-week study the researcher observed self-directed exploration, collaborative problem solving, and team work within the outdoor group. This occurred as students questioned why different trees had different bark, guessed when tree leaves would begin to appear, and actively collected piles of tree limbs that fell after various storms. Second grade

students were interested in life science topics generally covered in middle school classes because of tangible exploration. In addition to the self-exploration, problem solving occurred as one maze station included tossing bean bags to a partner alternating throwing and catching hands. Because of this station, numerous bean bags became stuck on tree branches with students collaborating and taking turns using their idea on the best way to knock the bean bag(s) down. During these times, students were redirected to the purpose of their outdoor visit – the maze. At the end of the maze students would work together to help the researcher "clean-up" the maze moving the 2x12 balance beam board and collecting maze props.

This study did not investigate if the outdoor setting contributed to the development of interpersonal skills or if perceived team work transferred to indoor collaborations during class lessons. Nevertheless, awareness of how one student's actions impacted the whole class was taught. For example, getting the bean bags stuck in the tree during the bean bag toss meant that the next students to come to that station could not fully participate in that activity. The indoor maze students do not have this opportunity to become acutely aware because a box of bean bags are available for them to use if the prior group has damaged the bean bag. Thus, after these outdoor maze interactions when students were circled up to do commands, if a student was struggling with a command or had missed the previous outdoor maze, the class would generally call out instructions or demonstrate the new commands to help the student(s) execute them correctly. These helpful hints most likely did not aid in increasing memory, but did enhance the process of learning which is equally valuable in the school setting.

The outdoor setting also aided in the ability for visual assessments of student performance. A majority of schoolwork is stationary with incorrect answers or comprehension not corrected until the misunderstanding is identified on returned homework or tests that signal

the end of a topic. Yet the outdoor setting allowed observation of kinesthetic, full body movements that could easily be identified as correct or incorrect comprehension. Utilizing outdoor settings to combine the process of learning with student self-exploration, aid in increasing interpersonal skills, and allow teachable moments to ensure correct comprehension points towards increased academic success and should be investigated further, since it was not in this study.

Limitations and Recommendations

The results of this study also should be viewed within the context of the limitations encountered. Substitute teachers created an interesting dynamic during the outdoor maze as some saw it as a positive opportunity for energy expenditure and others viewed it as an interruption. The ability for students to play in an outdoor setting was noted as a benefit of the study; however, the use of the outdoor maze as an incentive in which students became more engaged was not noted prior to the study.

Based on this research, the following recommendations are made for future study:

1. Future studies should investigate the lasting impacts of physical activity on students' academic success;
2. Future studies should investigate how physical activity effects short (working) and long term memory;
3. Future studies should qualitatively investigate how outdoor settings affect students' attitudes throughout the school day;
4. Future studies should investigate how memory among various demographics (i.e. socioeconomic status, race and ethnicity, gender) are effected by outdoor settings during the elementary school day

5. Future studies should investigate the impact outdoor physical activity has on students' overall academic performance;
6. Future studies should examine the level of physical activity relevant to intended educational standards/goals;
7. Future studies should examine the level of social support gained in classes participating in outdoor activities;
8. Future studies should examine the student-student and student-teacher dynamics among classes that participate in outdoor activities regularly.
9. Future studies should examine student attitude about the outdoor compared to the indoor maze, as positive mental affect is stated to occur when exposed to outdoor settings (Ulrich, 1984).

Although this study was conducted at a parochial school, is not believed that this skewed the results or limits the generalizability of outdoor settings for physical activity programs incorporated into the school day. There is no literature to suggest that non-public school students are exposed to more physical activity taking place in outdoor settings. This study lends itself to the assumption of memory increase incorporating physical activity occurring in outdoor settings into elementary school days.

Conclusion

The study set out to explore the influence setting of physical activity had on memory among elementary students. The general theoretical framework of the attention restoration theory (ART) (Kaplan & Kaplan, 1989) and psycho-evolutionary theory (PET) (Ulrich, 1984) was integrated with the empirically backed benefits of physical activity on cognitive functioning.

Taking students into an outdoor setting, surrounded by natural elements in which they could interact while the mind was able to relax and positive emotions were invoked were taken from ART and PET. Combined with the idea that physical activity lights up multiple areas of the brain charging the hippocampus with blood and brain-derived neurotrophic factor (BDNF) allowing hippocampal functions to increase. Both the indoor and outdoor groups increased in memory retention while the outdoor group did show greater memory improvements through memorization of correctly executed commands. The various components of outdoor settings with natural elements, peer socialization, teacher interaction and movement, are not able to occur within a typical elementary classroom students are generally confined too. Therefore, the physical movement and psychological changes stated within the theories that occur outside have led to increased memory and need to be sustained through continued physical movement in outdoor settings.

References

Änggård, E. (2011). Children's gendered and non-gendered play in natural spaces. *Children Youth and Environments*, *21*(2), 5-33.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological science*, *19*(12), 1207-1212.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of environmental psychology*, *25*(3), 249-259.

Bjorklund, D. F., & Brown, R. D. (1998). Physical play and cognitive development: Integrating activity, cognition, and education. *Child Development*, *69*(3), 604-606.

Bodrova, E., Germeroth, C., & Leong, D. (2013). Play and Self-Regulation: Lessons from Vygotsky. *American Journal of Play*, *6*(1), 111–123. Retrieved from http://eric.ed.gov/?id=EJ1016167

Brown, S. & Vaughan, C. (2009). Play: How it shapes the brain, opens the imagination, and invigorates the soul. New York: Penguin Group.

Burdette, H. L., & Whitaker, R. C. (2005). Resurrecting free play in young children: looking beyond fitness and fatness to attention, affiliation, and affect. *Archives of pediatrics & adolescent medicine*, *159*(1), 46-50.

Centers for Disease and Control Prevention. (2010). *The association between school based physical activity, including physical education, and academic performance.* Atlanta, GA: U.S. Department of Health and Human Services.

Chaddock-Heyman, L., Hillman, C. H., Cohen, N. J., & Kramer, A. F. (2014). III. The importance of physical activity and aerobic fitness for cognitive control and memory in

children. *Monographs of the Society for Research in Child Development*, *79*(4), 25-50. doi: 10.1111/mono.12129

Clayton, S. D. (2012). *The Oxford handbook of environmental and conservation psychology*. Oxford University Press.

Clements, R. (2004). An investigation of the status of outdoor play. *Contemporary issues of early childhood, (5)1*. 68-80. doi: 10.2304/ciec.2004.5.1.10

Cotman, C. W., & Berchtold, N. C. (2002). Exercise: a behavioral intervention to enhance brain health and plasticity. *Trends in neurosciences*, *25*(6), 295-301.

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends in neurosciences*, *30*(9), 464-472.

Corbin, L., & Marquer, J. (2013). Is Sternberg's memory scanning task really a short-term memory task? *Swiss Journal of Psychology*, *72*(4), 181.

Crain, W. (1997). How Nature Helps Children Develop. *Montessori Life*, *9*(2), 41-43.

Day, B. L., & Fitzpatrick, R. C. (2005). The vestibular system. *Current biology*, *15*(15), 583-586. doi:10.1016/j.cub.2005.07.053

Department of Health. (2005). C*hoosing activity: A physical activity action plan.* London, England: UK Department of Health.

Dobbert, M. L. (1985). Play is not monkey business! A holistic biocultural perspective on the role of play in learning. Educational Horizons 63(4), 158-163.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., Heo, S., McLaren, M., Pence, B., Martin, S., Vierira, V., Woods, J., McAuley, E., & Kramer, A, (2010). Exercise training increases size of hippocampus and improves

memory. *Proceedings of the National Academy of Sciences*, *108*(7), 3017-3022. doi: 10.1073/pnas.1015950108

Fleming, D. S., Allen, L. R., & Barcelona, R. J. (2011). Back to the future: The potential relationship between leisure and education. *New Directions for Youth Development, 130*, 43-57.

Francis, B. (2010). Gender, toys and learning. *Oxford Review of Education*, *36*(3), 325-344.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., Paus, T., Evans, A. C., & Rapoport, J. L. (1999). Brain development during childhood and adolescence: a longitudinal MRI study. *Nature neuroscience*, *2*(10), 861-863.

Graham, K. L., & Burghardt, G. M. (2010). Current Perspectives on the Biological Study of Play: Signs of Progress. *The Quarterly Review of Biology*, *85*(4), 393–418. doi:10.1086/656903

Griss, S. (1998). Minds in Motion: A Kinesthetic Approach to Teaching Elementary Curriculum. Teacher-to-Teacher Series. Portsmouth, NH.

Henricks, T. (2014). Play as Self-Realization: Toward a General Theory of Play. *American Journal of Play*, *6*(2), 190–213.

Higgins, P. (2002). Outdoor education in Scotland. *Journal of Adventure Education & Outdoor Learning*, *2*(2), 149-168. doi: 10.1080/14729670285200261

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: exercise effects on brain and cognition. *Nature reviews neuroscience*,*9* (1), 58-65. doi:10.1038/nrn2298

Hunt, J. (2008). Make room for daddy… and mommy: Helicopter parents are here. *The Journal of Academic Administration in Higher Education*, *4*(1), 9-11.

Iwaniuk, A., Nelson, J., & Pellis, S. (2001). Do big-brained animals play more? Comparative analyses of play and relative brain size in mammals. *Journal of Comparative Psychology* 115(1), 29-41.

James, W. (1890, 1950). The Principles of Psychology. New York: Dover.

Jensen, E. (2000). Moving with the brain in mind. *Educational Leadership, 58*(3), 34-37.

Kaplan, S. (1995). The restorative benefits of nature: toward an integrative framework. *Journal of environmental psychology, 15*, 169-182.

Kaplan, R. & Kaplan, S. (1995). The experience of nature: a psychological experience. Ann Arbor: Library of Congress Cataloging-in-Publication Data.

Kawulich, B. B. (2005). Participant Observation as a Data Collection Method. Forum: Qualitative Social Research 6(2). 5-27.

Martin, C. L., Eisenbud, L., & Rose, H. (1995). Children's Gender-Based Reasoning about Toys. *Child Development*, *66*(5), 1453-1471.

Myer, C. (2012). GR-8! Minds-in-Motion: How cranial nerve #8 can accelerate every student in America!

Nakamura, J., & Csikszentmihalyi, M. (2002). The concept of flow. *Handbook of positive psychology*, 89-105.

Nawaz, H. & Blackwell, S. (2014). Perceptions about forest schools: encouraging and promoting Archimedes forest schools. *Educational research and reviews, 9*(15). 498-503. doi: 10.1080/03004270802291798

Neubauer, A. C., & Knorr, E. (1998). Three paper-and-pencil tests for speed of information processing: Psychometric properties and correlations with intelligence. *Intelligence*, *26*(2), 123-151. doi: 10.1016/S0160-2896(99)80058-0

Neubauer, A. C., Riemann, R., Mayer, R., & Angleitner, A. (1997). Intelligence and reaction times in the Hick, Sternberg and Posner paradigms. *Personality and Individual Differences*, *22*(6), 885-894. doi:10.1016/S0191-8869(97)00003-2

Nicolopoulou, A. (1993). Play, cognitive development, and the social world: Piaget, Vygotsky, and beyond. *Human Development*, *36*(1), 1-23.

Noice, H., & Noice, T. (2001). Learning dialogue with and without movement. *Memory & Cognition*, *29*(6), 820-827.

O'Brien, L. (2009). Learning outdoors: the Forest School approach. *Education 3–13*, *37*(1), 45-60. doi**:**10.1080/03004270802291798

Olmsted, F. L. (1870). Public parks and the enlargement of towns. *The urban design reader*, 28-34.

Outdoor and Woodland Learning Scotland (2015). *Increasing opportunities for learning outdoors.* Retrieved from: http://owlscotland.org/about-us/

Paisley, K., Furman, N., Sibthorp, & Gookin, J. (2008). Student learning in outdoor education: A case study from the national outdoor leadership school. *Journal of experiential education 30*(3). 201-222. doi: 10.1177/105382590703000302

Pelosi, L., Hayward, M., & Blumhardt, L. D. (1995). Is "memory-scanning" time in the Sternberg paradigm reflected in the latency of event-related potentials? *Electroencephalography and Clinical Neurophysiology/Evoked Potentials Section*, *96*(1), 44-55. doi:10.1016/0013-4694(94)00163-F

Prinsloo, V. (2010). The role of the vestibular system in the learning process. *Mind Moves Institute.* 1-10.

Ratey, J. & Hagerman, E. (2008). SPARK: The revolutionary new science of exercise and the brain. New York City: Hachette Book Group USA.

Reese, W. J. (2001). The origins of progressive education. *History of Education Quarterly*, *41*(1), 1-24. doi: 10.1111/j.1748-5959.2001.tb00072.x

Reilly, E., Buskist, C., & Gross, M. K. (2012). Movement in the classroom: Boosting brain power, fighting obesity. *Kappa Delta Pi Record*, *48*(2), 62-66. doi:10.1080/00228958.2012.680365

Ruscheweyh, R., Willemer, C., Krüger, K., Duning, T., Warnecke, T., Sommer, J., Volker, H., Mooren, F., Knecht, S., & Flöel, A. (2011). Physical activity and memory functions: an interventional study. *Neurobiology of aging*, *32*(7), 1304-1319. doi:10.1016/j.neurobiolaging.2009.08.001

Salmon, P. (2001). Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. *Clinical psychology review 21*(1). 33-61.

Sattelmair, J., & Ratey, J. J. (2009). Physically active play and cognition. *American journal of play*, *3*, 365-374.

Sibley, B. A., & Etnier, J. L. (2003). The relationship between physical activity and cognition in children: a meta-analysis. *Pediatric exercise science*, *15*(3), 243-256.

Spencer, J. (2004). Understanding child development. *Child Development*, *4*, 16–21. doi:10.1108/17473610510814372

Staley, F. (1979). *Outdoor Education for the Whole Child*. Dubuque: Kendall/Hunt Publishing Company.

Stroth, S., Hille, K., Spitzer, M., & Reinhardt, R. (2009). Aerobic endurance exercise benefits memory and affect in young adults. *Neuropsychological Rehabilitation*, *19*(2), 223-243. doi**:** 10.1080/09602010802091183

Taylor, A. F., Kuo, F. E., & Sullivan, W. C. (2002). Views of nature and self-discipline: Evidence from inner city children. *Journal of environmental psychology*, *22*(1), 49-63.

Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention. *Journal of environmental psychology*, *15*(1), 77-85.

Trost, S. G., & van der Mars, H. (2009). Why we should not cut PE. *Educational leadership*, *67*(4), 60-65.

Ulrich, R. (1984). View through a window may influence recovery from surgery. *Science. 224*(4647). 420-421.

Van Praag, H. (2009). Exercise and the brain: something to chew on. *Trends in neurosciences*, *32*(5), 283-290.

Voss, M. W., Prakash, R. S., Erickson, K. I., Basak, C., Chaddock, L., Kim, J. S., Alves, H., Heo, S., Szabo, A. N., White, S. M., Wojcicki, T. R., Mailey, E. L., Gothe, N., Olson, E.

A., McAuley, E., & Kramer, A. F. (2010). Plasticity of brain networks in a randomized intervention trial of exercise training in older adults. *Frontiers in aging neuroscience*, *2*(32), 1-17. doi: 10.3389/fnagi.2010.00032

Voss, M. W., Erickson, K. I., Prakash, R. S., Chaddock, L., Kim, J. S., Alves, H., Szabo, A., White, S., Wójcicki, T., Mailey, E., Olson, E., Gothe, N., Potter, V., Martin, S., Pence, B., Cook, M., Woods, J., McAuley, E., & Kramer, A. (2013). Neurobiological markers of exercise-related brain plasticity in older adults. *Brain, behavior, and immunity*, *28*, 90-99. doi:10.1016/j.bbi.2012.10.021

Winsler, A. (2003). Early Education and Development INTRODUCTION TO SPECIAL ISSUE : Vygotskian Perspectives in Early Childhood Education : Translating Ideas into Classroom Practice Vygotskian Perspectives in Early Childhood Education : *Early Education & Development*, *14*(3), 37–41. doi:10.1207/s15566935eed1403

Appendix A

MINDS-IN-MOTION, INC.

AUDITORY DIGIT SPAN ASSESSMENT

(compiled by Minds-In-Motion, Inc.; based upon protocols by Dr. Robert Doman)

Say numbers in monotone voice...slowly....in one second intervals. Have student repeat them. Determine student's highest numerical digit span by starting with a 2 digit, then a 3 digit, and working up to the highest level of competency.

2 DIGIT	3 DIGIT	4 DIGIT	5 DIGIT	6 DIGIT	7 DIGIT
1-6	2-4-1	9-4-2-9	3-9-2-1-4	5-2-1-6-9-2	3-9-2-1-4-2-8
2-9	5-2-8	6-3-1-8	8-9-6-4-5	6-9-3-8-9-4	8-1-6-4-5-8-4
8-3	9-3-6	5-2-3-1	1-4-9-3-6	3-2-9-1-5-6	1-9-4-6-2-3-1
9-5	6-1-9	6-4-9-2	6-3-8-4-2	8-6-2-4-5-9	6-8-3-2-4-1-9
2-6	4-8-3	1-3-4-8	5-2-1-9-5	1-4-9-1-3-2	5-1-9-6-9-2-3
4-2	5-2-6	2-5-6-1	2-8-3-6-1	2-6-4-3-9-8	2-3-8-1-6-4-3
6-1	8-5-9	4-1-9-4	5-4-6-2-3	9-5-1-2-4-5	8-6-4-2-3-6-5
8-5	6-4-2	8-6-5-3	9-5-1-2-4	3-6-8-4-1-6	9-1-5-2-4-6-1
2-9	1-8-3	9-4-2-5	6-3-5-8-9	5-2-9-1-6-4	6-4-3-9-8-3-8
6-3	3-9-1	3-8-6-4	4-9-5-2-5	9-8-4-2-6-3	4-5-8-2-5-1-3

Pre-assessment _____ _____ _____

Date Score Age

_____

Student name

Post-assessment _____ _____ _____

Date Score Age

Scoring notes:

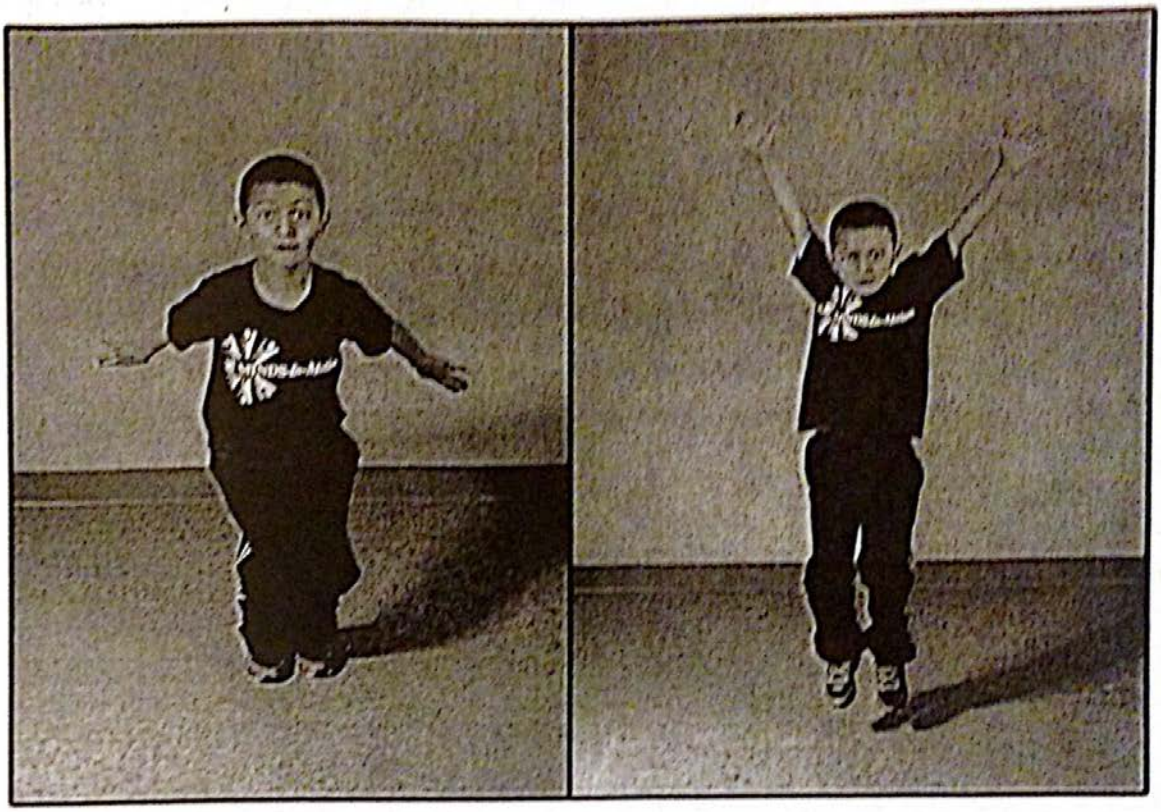
Start with the easiest column and try a few until you find the column that seems hard for the student. Go back to the preceding column and give all of those. Then move to the harder column. Circle the ones he/she gets correct.

Example: If Tommy gets all (or most all) of Column 3 correct, and gets 6 right in the next column, then his score is 3.6.

Appendix B

GR-8! Minds-in-Motion

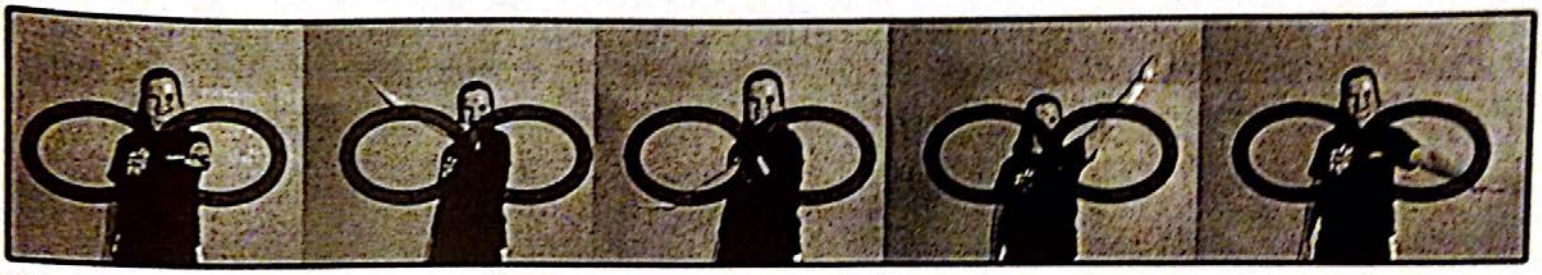
Jump



Bend knees,
then propel body straight up in the air.

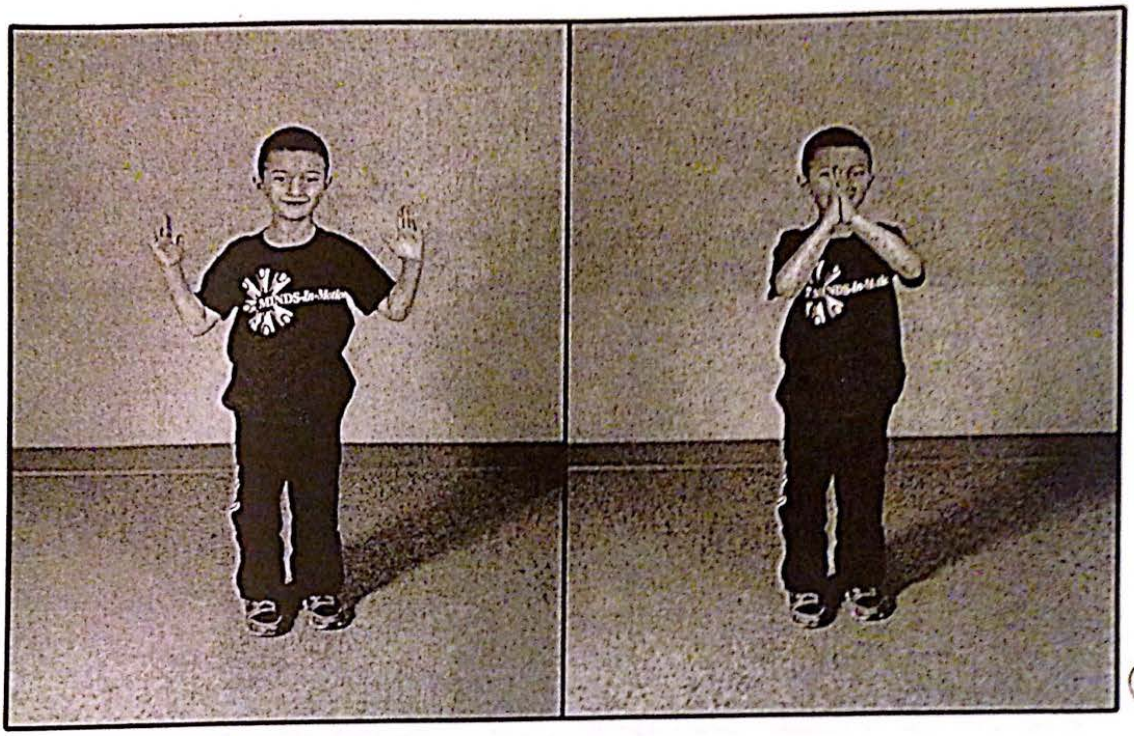
GR-8I Minds-in-Motion

Eight



With arm straightened out in front of body, trace an 8 (∞-lying on its side) in the air.

Clap

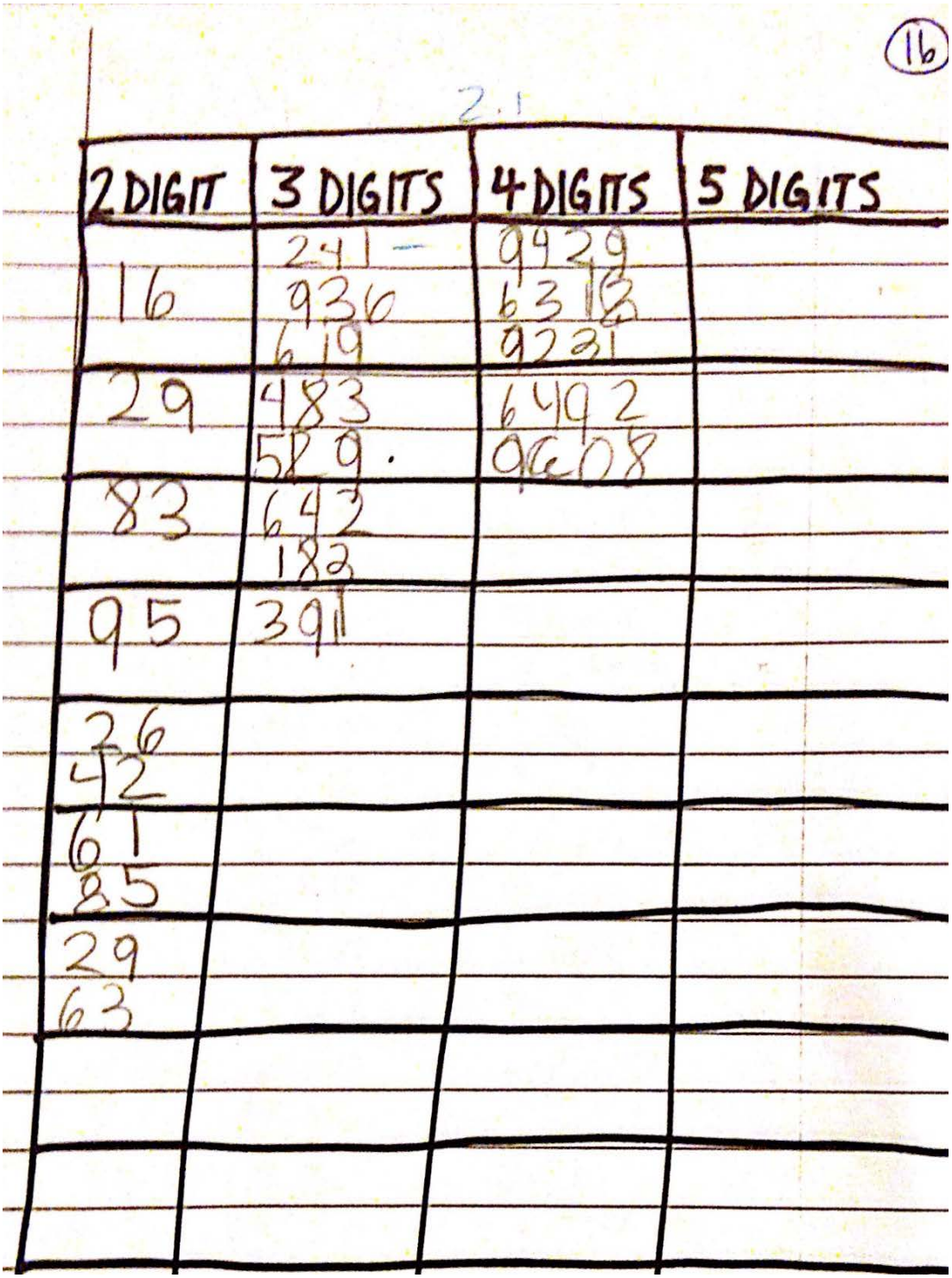


Standing in place,
clap your hands together one time.

GR-8I Minds-in-Motion

Skate

Slide one foot to the side, swaying your body to the same side. Then slide the other foot to the other side, swaying the body to the opposite side. Bend your arms & move arms in rhythm with legs.



16

2.1

2 DIGIT	3 DIGITS	4 DIGITS	5 DIGITS
16	241 —	9929	
	936	6318	
	619	9281	
29	483	6492	
	589.	9608	
83	643		
	182		
95	391		
36			
42			
61			
85			
29			
63			

(17)

3.1

2 DIGIT	3 DIGITS	4 DIGITS	5 DIGITS
16	241	9429	
29	528.	6328X	
83	936	5231	
95	619.	6492	
26	483	1348	
42	526	2561	
61	859	4194	
85	642	8653	
29	183	9425	
63	391	3864	