GREEN PLAY: RESTORATIVE NEUROBEHAVIORAL EFFECTS ON ADHD CHILDREN

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ABSTRACT

Background. One in ten U.S. children has been diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD). ADHD children are characterized by their inability to hold sustained-attention and regulate their hypervigilance. Previous studies have shown that exposure to greenspace can reduce ADHD symptoms. This study examined whether 30 minutes of play in a greenspace aided in increasing sustained-attention ability and hypervigilance regulation. **Methods.** Eleven children ages 7 to 13 years old participated in a neurological test which included a pre-and post-electroencephalogram scan (EEG) to measure their theta beta ratio (TBR). Children then participated in a continuous performance test (CPT) to measure their behavioral functioning and a perceived restorative scale (PRS-ii) to measure their perceptions of the greenspace. **Results.** EEG scans were inconclusive, and numerous ideas for further research are reported. CPT results suggest that children who participate in green play have increased sustained-ability when compared to other studies noted in the literature. The PRS-ii results suggested that the children found the greenspace restorative. **Conclusions.** These findings suggest that while ADHD children deem green play restorative, further evidence is needed of the effects of greenspace on neurological and behavioral functioning.

Keywords: ADHD; children; greenspace; sustained-attention; hypervigilance; neurobehavior

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Nine summers ago our world turned upside as we met a hyperactive seven-year old who was jumping up and down in front of a church pew. She wouldn't become our foster daughter for nine months or adopted daughter for another year, but she did take our hearts that day. The pages that follow are for Sarah Jewelann Wilson-- a girl with big dreams, big hopes, and a heart larger than her body. May your life forever be influenced by the GOD that just is-- the holy one that is apparent in the rocks, trees, oceans, skies, stars, and moons. Thank you to my husband, Captain Charles MacPhail Wilson, who has guided our family and my life through good seas and rough ones. Thank you for allowing countless nights of empty sleep so that I could read, write, and research. Thank you to my dad, Jerry Bates, for nights in sleeping bags in the California woods. Those moments changed my heart, mind, and soul. Thank you to my mom, Debbie Ward, for teaching me to learn until I am grey. Thank you to Dr. Julie Onton of University of California San Diego and Dr. Ed Hamlin of the Center of Advancement of Human Potential for your insight in understanding the intricate and developing world of neuroscience. Thank you to Brad Daniel, my mentor and friend. Your ability to love students, including the "crazy ones" will forever be etched in my heart and mind. Thank you for your prodding reminders, long coffee talks, and walking with me for over eighteen years. Thank you to Dr. Brad Faircloth, my committee member and friend. Your insight and depth of knowledge and spirit are always a great encouragement. Thank you to Dr. Dottie Shuman, a teacher and friend for over eighteen years. Thank you for the friendship and the beautiful program that you have built. Lastly, thank you to Montreat College community. You truly stand in noble line.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1.

INTRODUCTION AND STATEMENT OF THE PROBLEM

Attention deficit and hyperactivity disorder (ADHD) is the most diagnosed neurobehavioral disorder in the United States (Furman, 2005) with a prevalence rate of 9.5% of school-age children (Center for Disease Control [CDC], 2011; Cormier, 2008). Likewise, 4.3% of American children have been diagnosed with ADHD and have taken medication to treat its symptoms (CDC, 2003). For many families, routine tasks such as homework are causing stress on children and family members alike. Educational systems are scrambling to meet the needs of ADHD children since they often have difficulty participating in classroom structures and routines (Reid, 1999). While numerous interventions including self-regulation techniques (Danforth, 2008; Montague & Warger, 1997; Reid, 1999), stimulants (Montague & Warger, 1997; Swanson, McBurnett, Wigal, Pfiffner, Lerner, Fisher, 1993), and neurofeedback (Arns, Conners, & Kramer, 2011; Arns & Kenemans, 2012) have all been well documented, Solar Intensity as an ADHD preventative is a new area of study (Arns, Van der Heijden, Arnold, & Kenemans, 2013). Solar Intensity (SI) or the use of morning light therapy (LT) is a treatment that places the subject in front of a light box or outside in natural light for a certain period of time, generally 30 minutes or more. This emerging research corresponds with the benefits of restorative environments in Kaplan's attention restoration theory (ART) (Cole & Hall, 2010; Kaplan & Kaplan, 1989; Kaplan, 2001).

Since the dawn of time the human population has turned to nature as a restorative force. Countless religions have used nature to treat physical, emotional, mental, and spiritual illness (Berger & Mcleod, 2006). Environmental activists such as Rachel Carson, Henry David Thoreau, John Muir, Aldo Leopold and Standing Bear have spoken of nature's ability to sooth the heart and bring rejuvenation to the mind (Louv, 2007; Mayer, Frantz, Bruehlman-Snecal, & Dolliver, 2009). Great educators such as Rousseau, Agassiz, Comstock, Jackman, Montessori, Emilia, and Dewey have written on the fortitudes of nature in classroom. Countless researchers have spoken of nature's potential to restore attention (Chawla, 2001; Faber-Taylor & Kuo, 2008; Kahn & Kellert, 2002; Kaplan, 1989). In 2007, a global dialogue on "nature deficit-disorder", a term coined by Louv (2007) in his bestseller *Last Child in the Woods*, gained momentum, and movements such as No Child Left Inside grew in popularity. As we enter an era of education reform, those in and out of educational settings need greater insight into nature's effects on children diagnosed with ADHD.

Background

Educational desideratum. Perold (2010) revealed that traditional classroom teachers have little knowledge of ADHD symptoms and interventions. Since eighty-five to ninety percent of children diagnosed with ADHD participate in traditional classrooms, new low-cost, research-based interventions are essential (Burcham & Carlson, 1993). Children diagnosed with ADHD commonly perform low academically (Monastra V., Monastra D., & George, 2002; Nikolas & Burt, 2010) and have comorbid learning disorders (McKinney, Montague, & Hocutt, 1993). Many of these children qualify for exceptional children (EC) programs or educational accommodations constituted by Section 504 of the 1973 Vocational Rehabilitation Amendments (504 plans). In a 2004 restatement of the Individuals with Disabilities Education Act (IDEA), the United States government declared that federal EC funding hinges on inclusion of all students. Perold's data implies a greater need for teacher understanding of ADHD students for districts mandated by IDEA and 504 plans.

Current classroom interventions require manipulating classroom environments to best-fit children's needs, yet pharmacological interventions have become common practice for treating ADHD. "Present estimates suggest that approximately 60% to 90% of all students who have been diagnosed with ADHD will be on a medication program" (Montague & Werder, 1997, p. 12). Stimulants alone do not completely alter behaviors, which distract from academic learning. A broader reach of educational interventions will assist in decreasing behavioral symptoms and increasing academic performance. Likewise, current research suggests that there is a a sub-group of ADHD children, those diagnosed with idiopathic sleep-onset insomnia (SOI) or delayed sleep phase syndrome (DSPS). Studies suggest that Solar Intensity (SI) explains 34-41% of the variance in ADHD due to SI's effect on circadian pacemakers (Lewy et al., 1992; Mundey et al., 2005; Nagtegall et al., 1998a). It is imperative that we begin to reconsider the role of environment on attention deficit and hyperactivity. Therefore, the purpose of this study is to explore the neurobehavioral benefits of vegetated outdoor play environments on ADHD children.

CHAPTER 2.

LITERATURE REVIEW

ADHD: Characteristics, Causes, and Diagnosis

Characteristics of ADHD. Characterized by two primary behaviors, inattention and impulsivity/motor hyperactivity, ADHD is a significant obstacle to children in educational settings (Barkley, 1998; Lahey, et al., 1988). Behavioral signs of inattention are distractibility and difficulty concentrating/organizing tasks (Montague & Warger, 1997). Other indicators of inattention are shifting frequently from one activity to another, failing to finish given tasks, and the appearance of not listening (Lahey et al., 1988). Children that are inattentive are often spotted staring out classroom windows or shifting in their seats.

Inattention once led researchers to believe that ADHD children were incapable of sustained-attention. However, Montague and Warger's study (1997) concluded that inattention is primarily due to attentional bias, not lack of attention ability. Attentional bias as defined by Zentall (1993, p. 143) states that ADHD children have "adequate attention, memory, and comprehension, but associated to specific tasks, time periods, and conditions". Teachers and parents alike have witnessed ADHD children engrossed in classic novels, building Lego cities and fortresses for hours, and collecting insects until sundown with determined attention. Many ADHD children spend sustained time on activities they perceive as valuable or engaging. Copeland and Wisniewski (1981) detected that ADHD children often feel more engaged by tasks with increased stimuli such as varying colors, sizes, or movement to be engaging.

Figure 1 Defining ADHD characteristics

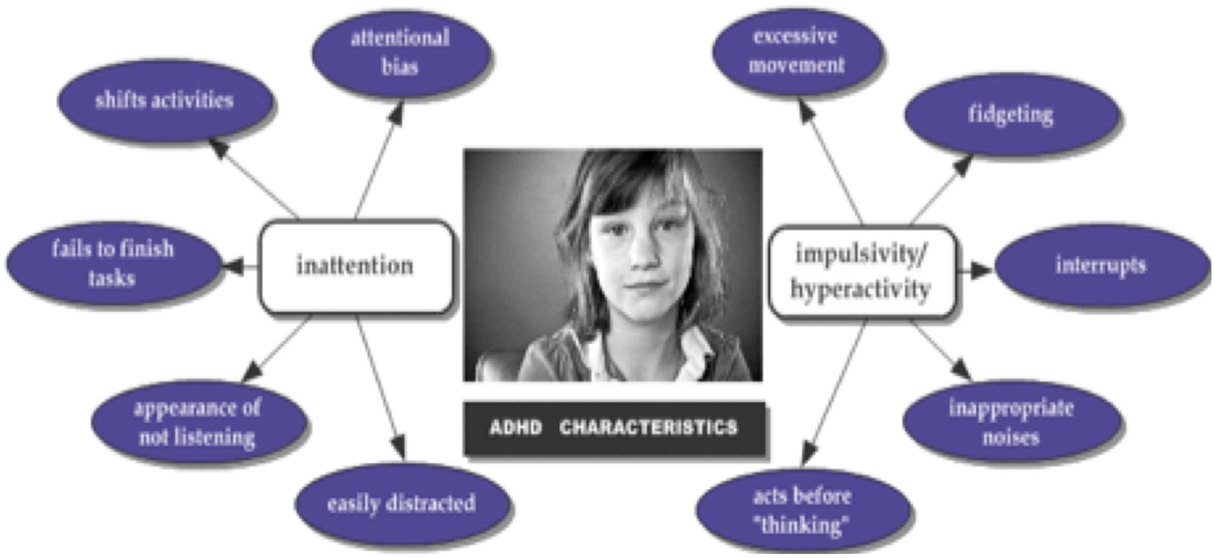

Figure 1. Comparisons of two majors components of ADHD, inattention and hyperactivity using characteristics referenced by Barkley, 1998; Lahey et al., 1988; Taylor et al. 2006.

Additionally, ADHD children deem tasks that are new or novel to be valuable and attention provoking (Zentall, 1993). These types of tasks, comprised of novelty and stimulant-rich experiences, are selected-attention tasks. When experiencing selected-attention tasks, ADHD children generally miss neutral or subtle nuances and are unable to focus on embedded tasks or intricate details (Montague & Warger, 1997; Zentall, 1993). Therefore, mathematics procedures that require multiple steps such as long division or research paper assignments with numerous edits can frustrate ADHD children.

Sustained-attention, conversely, is classified as attention that requires a "stable level of performance" (Zentall, 1993, p. 144). Repetitive tasks that the child has amply experienced, or that are subtle with little engagement, are considered sustained-attention tasks. Due to attentional bias, ADHD children will engage in sustained-attention tasks; however their performance will worsen with repetitive stimuli, decreased novelty, and increased time on-task. Indicators of children struggling with a sustained-attention task are frequent errors or increased body movements (Montague & Warger, 1997; Zentall, 1993). Excessive movements, fidgeting, motor restlessness (i.e. hair twirling, pen tapping, nose picking, grabbing), difficulties staying seated, impatience, noises at inopportune times, or talking without being called on are all examples of impulsivity/motor hyperactivity (Lahey et al., 1988; Montague & Warger, 1997). The neurological explanation behind attentional bias and impulsivity is attributed to n under-aroused brain (Hamlin, personal communication, August 26, 2015).

Causes of ADHD. The cause of ADHD is hypothesized to be a combination of genetics and environment. Current research states that seventy-seven percent of the diagnosis is due to heritability while twenty-three percent is due to environment (Banjeree, Middleton, Faraone, 2007; Nikolas & Burt, 2010). Equally valid is the hypothesis that a homogenization of genetics and environment has increased current ADHD diagnoses (Nikolas & Burt, 2010).

ADHD is the most researched disorder to date (Rowland, Lesesne, & Abramowitz, 2002). Since no definitive standard exists for ADHD heritability prevention through technological gene-mapping (Furman, 2005), the majority of clinicians focus on environmental factors. Psychosocial adversities such as family type or maltreatment/trauma are current areas of study. As well, the association of ADHD and early childhood television viewing (Banjeree et al., 2007; Nikolas & Burt, 2010) is a prevalent topic.

Due to its neurobehavioral disposition, ADHD is frequently comorbid, or combined with other disorders. Post-traumatic stress disorder (PTSD) increases hypervigilance (fear of perceived dangers) therefore mimicking hyperactivity. Additionally, PTSD and/or trauma from sexual abuse leads to hypervigilance. Forty-six percent of sexually abused children are diagnosed with ADHD and display concentration and attention problems as well as hyperactivity (Banjeree et al., 2007). Hart et al. (2005) reported that compulsive hoarders also exhibit greater hyperactivity and inattention. Besides these psychosocial adversities, several biological adversities have been identified (Arns et al., 2011; Banjeree et al., 2007). Regarding the relevance to this study, it is important to note the comorbidity of ADHD, since the neurological processes behind these disorders could vary from the exclusively ADHD brain. Furthermore, biological adversities could affect brain functioning and show a neurological difference to the ADHD brain.

Banjeree et al. (2007) reported several biological adversities that contribute to hyperactivity and impulsivity including poor prenatal care and delivery complications, fetal alcohol exposure, and maternal prenatal tobacco use increase. Studies on environmental toxins such as mercury, lead, and manganese have also been conducted. Children exposed to to mercury-contaminated fish experience a negatively affected IQ (i.e. language, motor, and visual-spatial delays) and memory and attention issues (Banjeree et al., 2007). Found in high doses in breast milk, bio-accumulated Polychlorinated biphenyls (PBCS) are linked to poor attention, decreased accuracy, and slower reaction times. Studies on diet, specifically food additives, are of equal interest; however, currently little evidence for this association with ADHD has been established (Banjeree et al., 2007).

Despite all of the research to help explain the causes of ADHD, one area that needs further attention is the role that environment has on the brain development of children diagnosed with ADHD. Recently, studies investigating brain activity, especially using electro-encephalography (EEG) (a record of electrical impulses across the scalp that measures the voltage fluctuations of neurons) has furthered our understanding of biological and neurological implications of ADHD sub-types (Arns et al., 2011). Once only available to a handful of neuroscientists, EEG technology is making its way to the mass market, allowing for further exploration of the brain and ADHD.

Diagnosis of ADHD. The prevalent diagnosis protocol is provided by *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V) (4th ed., text. rev.; American Psychiatric Association [APA], 2000), which was developed to rate children's symptoms across varied settings (i.e., home and school), times (i.e., morning, weekends, bedtime), and tasks (i.e., reading, playing at the park, homework). Children's symptoms are observed/identified by at least two parties, generally parents and teachers, but may be further observed by clinicians (e.g., pediatricians, psychologists, counselors) (Frick & Lahey, 1991; Montague & Warner, 1997).

According to the American Pediatric Association (APA), children must have displayed symptoms prior to their seventh birthday for at least six months, and symptoms must persist across settings (2004). Synthesis of data across settings combined with collaboration of observers warrants greater validity (Montague & Warner, 1997). Yet, due to the "observational" nature of data, debate exists on whether pediatricians should diagnosis ADHD as a disorder. Currently, boys are labeled with an ADHD diagnosis 4:1 to girls (Singh, 2004), creating greater controversy on its neurological or behavioral status. Further research into neurology and gene mapping demands further research (Furman, 2005).

The last decade of research on the elevated theta/beta ratio (TBR) found in EEG scans of

ADHD children establishes its neurological status (Arns et al., 2012). The dissonance between high theta ranges and low beta ranges within the ADHD brain aligns with children's inability to sustain attention and their impulsivity/hyperactivity (Arns et al., 2012). Increased research using TBR as a prognostic tool is necessary to further conceptualize TBR's effect on behavior including hyperactivity or vigilance. This study will use the TBR to aid in quantifying sustained-attention and impulsivity/hyperactivity.

EEG Vigilance Model & ADHD Subtypes

EEG vigilance. Vigilance and the ability to respond to internal and external environments are essential to the viability of any species. High vigilance levels occur in environments deemed dangerous, and reduced vigilance occurs during times of recreation. This can also occur conversely, whereby the individual can create an environment dependent upon their vigilance level (Eysenck, 1990; Ulrich, Renfordt & Frick, 1986; Zuckerman, 1985). Sleep generally occurs as the vigilance level is reduced and as the environmental stimulation lessens; however, under certain situations, hyperactivity and sensation-seeking can become a compensatory behavioral pattern termed 'vigilance auto-stabilization behavior' (Arns & Kenemans, 2011).

A generalized "everyday" example would be that of a healthy adult who decides to retreat to her bedroom with a book for the night as the environment of the day begins to fade and vigilance is no longer required. Yet, if that same healthy adult was driving a car and this type of EEG pattern materialized, she would roll down the windows, turn up the radio, make a phone call, dance in her seat, and so on, to create an environment of stimulation, thus keeping regulating her vigilance level. Despite the adult's auto-stabilization behavior, if a car in front of them brakes, she is more likely to have impaired sustained-attention as well as the possibility of a car accident (Arns & Kenemans, 2011). One wonders if the 1 in 10 ADHD children we see in America's classrooms (Center for Disease Control [CDC], 2011) is simply a set of tired children who are trying to compensate for their drowsiness with hypervigilant behaviors?

ADHD sub-type: sleep onset insomnia. Vigilance auto-stabilisation behavior can correspondingly be attributed to sleep-deprived children (Astill, Heijden, Ijzendoorn, & Someren, 2012). A 2012 meta-analysis assimilated the the results of 35,936 healthy children, and reported that sleep-duration is negatively correlated with internalizing and externalizing behavioral problems, and positively correlated with school performance and executive functioning (Astill et al., 2012). Day-time sleepiness (Golan, Shahar, Ravid, & Pillar, 2004), primary sleep disorders, and sleep related movement disorders have all been associated with ADHD (Chervin et al. 2002; Konofal et. al. 2010; Walters et al., 2008), and ADHD symptoms can be induced within healthy children that experience sleep-disruptions (Beebe et al., 2008; Fallone et al., 2001, 2005; Sadeh et al., 2003).

Children that are unaffected by stimulate medication, can still experience a reduction in symptoms by normalizing their sleeping patterns (Walters et al., 2000). Sleep-onset insomnia (SOI) or delayed sleep phase syndrome (DSPS) in ADHD manifests in difficulty falling asleep at a desired bedtime and/or latency of sleep-onset more than 30 minutes for at least four nights a week over a minimum of 6-12 months. SOI differs from a sleep-disorder in that it is characterized by difficulty falling asleep that manifests before the age of 3 years old (Van deer Heijden et al., 2005), and is associated with delayed Dim Light Melatonin Onset (DLMO) (Van deer Heijden et al., 2005; Van Veen et al., 2010). DLMO suggests a circadian phase delay, one of the prevalent sleep disorders being researched currently (Pandi-Perumal et al., 2007).

72-75% of unmedicated ADHD children suffer from SOI (Van deer Heijden et al., 2005). This sub-group of ADHD children is characterized by elevated frontal theta ranges and/or alpha ranges, allowing them to respond positively to stimulant medications (Arns et al., 2008). Though effective in treating ADHD behavioral symptoms, stimulant medications do not correct the circadian phase delay, which is the root cause of lower vigilance levels neurologically. Conversely, recent studies have shown the efficacy of exogenic melatonin in SOI/DSPS patients and its ability to correct circadian rhythms (Lewy et al., 1992; Mundey et al., 2005; Nagtegall et al., 1998a). If exogenic melatonin is able to correct circadian rhythms, it is valuable to consider natural melatonin catalysts such as early morning bright light's effect on SOI sub-group of ADHD children.

EEG vigilance model. Normal sleep patterns follow stages based on the Rechtshaffen and Kales criteria (1968). Stages 1-4 transition from stage 1, non-rapid eye movement sleep (NREM) and increase to stage 3, slow wave sleep (SWS), and stage 4, rapid eye movement sleep (REM) (Arns & Kenemans, 2012). An extension of this model, the EEG-vigilance algorithm (VIGALL) has been developed and modified to classify the stages of wakefulness that the human brain experiences when transitioning from alertness to sleep onset (Bente, 1964; Klimesch, 1999; Loomis et al., 1937; Roth, 1961; Ulrich & Frick, 1986). The vigilance stages classified by VIGALL are measured in resting state eyes closed condition (Arns & Kenemans, 2012).

Beginning with stages A1, the VIGALL defines the decreasing stages of vigilance. Stage A1, reflects dominant posterior alpha activity, often referred to as an "idling rhythm", or relaxed wakefulness (Niedermeyer, 1997), while A2/3 reflect alpha power moving anteriorly causing a slight decrease in frequency and resulting in a transition to drowsiness (Broughton & Hasan, 1995; Connemann et al., 2005; De Gennaro, Ferrara, Curcio & Cristiani, 2001; De Gennaro et al., 2004; De Gennaro et al., 2005; Pivik & Harman, 1995). B1 stages represent an alpha drop-out or low EEG with a beta frequency increase corresponding to intense mental activity present during an eyes open condition (Roth, 1961). Increased frontal theta and delta activity occur in B2/3 (Arns & Kenemans, 2012), increasing drowsiness (Strijkstra, Beersma, Drayer, Halbesma & Daan, 2003; Tanaka et al., 1996; Tanaka et al., 1997). Drowsiness transitions to the occurrence of K-complexes and sleep spindles in stage C, marking the beginning of NREM (Cash et al., 2009; De Gennaro & Ferrara, 2003; Tanaka et al., 1997).

EEG vigilance stages can be mobile or unstable, dropping to frontal theta stages B2/3 very quickly (Arns & Kenemans, 2012). This pattern of variable B2/3 vigilance stage is necessitated by 'excess theta' resulting in subjective drowsiness and is often reported in ADHD children (Sander et al., 2010). Behaviorally, drowsiness materializes into vigilance auto-stabilization (e.g. hyperactive, impulsivity, and talkativeness). The most consistent EEG findings state that there is an increased absolute power in theta and a decreased absolute beta in ADHD children (Bresnahan et al., 1999; Chabot & Serfontein, 1996; Clarke et al. 1998, 2001; DeFrance et al., 1996; Janzen et al. 1995; Lazzaro et. al. 1998, 1999; Mann et al. 1992; Matsuura et al. 1993), yet two other neurophysiological sub-groups have been reported: an excess beta group (Arns, 2012; Clarke et al., 2011; Callaway Halliday & Naylor, 1983; Mann et al., 1992; Matsuura et al., 1993) and an increased absolute power delta group (Bresnahan et al, 1999; Clarke et al., 2001; Kuperman et al., 1996). However, coverage of these sub-groups is beyond the scope of this study.

Current ADHD Interventions

The irregularity of high frequency theta and low frequency beta during times of needed concentration greatly affects outward behavior in at least two known areas: sustained-attention ability and hypervigilance regulation (Arns et al., 2012). For parents and teachers of ADHD children, life is widely altered. Therefore, parental, pharmacological, self, educational, and neuropsychological interventions have been developed. While our media induced culture views "Ritalin" and subsequent stimulants as the primary ADHD intervention, the American Pediatric Association (APA) notes that stimulants should not be a primary treatment approach (1987). Instead a heterogeneous intervention plan should be explored.

Parental and self-interventions. Current child self-monitoring and management techniques have been slightly successful (Montague & Warner, 1997; Reid, 1999). Reid (1999) explains monitoring as a system in which children can rate their display of symptoms at consistent intervals throughout a task or learning period. In a classroom setting a small timer or tone is used at a child's desk as well as a behavior checklist; when the child hears the tone they self-rate and work to change behavior if necessary.

A similar form of self-intervention is a management technique in which both the teacher/parent and child rate the child's behaviors at intervals throughout the day. This enhanced feedback has shown greater results, yet this is laborious (Reid, 1999) and requires one-on-one training with the child by the primary caregiver.

Danforth's (2008) study reported that parenting style and home life contributes to ADHD prevalence. Banjeree, Middleton, and Faraone's (2007) review of environmental contributions confirms Danforth's findings. Yet, new research in this area seems less beneficial since children spend six to seven hours away from their parents daily. Instead, new or revised educational interventions seem more valuable, such as increased time outside at school or natural settings that will aid in proliferating natural melatonin production in SOI subgroups of ADHD children, and possibly wake under-aroused high frequency theta/low frequency beta children from their waking slumber.

Educational interventions. Current best educational practices for assisting ADHD children in the classroom do not address the potential of outdoor play or natural settings as interventions. Instead, they combine self-monitoring and management with frequent parent-teacher communication and strategic manipulation of the classroom environment (Montague & Warger, 1997). It is believed that classroom environments should consist of four walls (rather than open pods), have a low student-to-teacher ratio, and involve children working at individual desks (Montague & Warger, 1997). Likewise, ADHD children should be seated near the teacher, and peer distractions and extraneous (non-educational) stimuli should be limited. Kinesthetic learning tasks and standing work in the classroom should be emphasized to capitalize on children's need for ancillary movement (Montague & Warger, 1997). Yet, if ADHD children are truly under-aroused neurologically, a highly stimulating and novel environment rather than a safe and predictable environment seems like a more effective educational intervention.

Best daily classroom routines for ADHD children begin with core subjects in the morning and hands-on learning in the afternoons, thus allowing selected-attention tasks to follow sustained-attention tasks (Montague & Warger, 1997). This means ADHD children's non-preferred tasks should be completed before preferred (Burcham & Carlson, 1993; Montague & Warger, 1997; Reid, 1999) since preferred task correlate to selection-attention tasks. Knowing that attention will increase when a child perceives a task as novel, authentic, and worthwhile, this study is interested in knowing if play in a novel setting impacts ADHD children's abilities to return to sustained-attention tasks. Additionally, the study hopes to determine if outdoor play affects vigilance regulation.

Manipulation of classroom environment and establishment of rules and procedures are principal, yet varied curriculum and instruction is often difficult (Burcham & Carlson, 1993; Reid, 1999). Instruction for ADHD children should increase novelty in order to appeal to their attentional bias (i.e., their willingness to only pay attention to what they are interested in, rather than what is required of them cognitively). Varying textures, formats, motor responses, and the use of high to low interest tasks are needed to capture their attention. Relevant and authentic learning allows for greater choice by the child and leads to strengthened enthusiasm for the subject and therefore increased selected-attention (Burcham & Carlson, 1993; Reid, 1999). In addition, appropriate scaffolding to children's abilities is necessary, and task length should be shortened or condensed into succinct segments (Burcham & Carlson, 1993; Montague & Warger, 1997; Reid, 1999).

Researchers (Elliot, Witt, Joseph, Glavin & Moe, 1996; Reed et al., 1997) suggest that involving other classmates in encouraging appropriate behavior can help with this process. Social skills training is found to be beneficial to classroom accommodations (Montague & Warger, 1997). The relevance of this to this study, is that a environmental change to an outdoor play space or might aid in restoring children's attention for when they return to the classroom. In addition, since ADHD children are often stereotyped as behavioral problems, it is crucial that a positive classroom community is established. Could outdoor play aid in establishing lasting social connections with their classmates?

Pharmacological interventions. Current research states that after self, parental, and educational techniques are practiced, certain ADHD children will still require further support and interventions (Montague & Warger, 1997). Pharmacological interventions are shown to greatly diminish symptoms (Montague & Warger, 1997). Stimulant use is the primary pharmacological intervention; however new interventions are being developed yearly. Stimulant use has become stigmatized among mothers, due to media reporting or social influences (Jackson & Peters, 2008), yet seventy-five percent of cases show immediate and drastic changes (Swanson, McBurnett, Wigal, Pfiffer, & Learner, 1993). Changes not only include increased sustained-attention, but improved cognitive control and academic performance (Montague & Warner, 1997).

Yet, pharmacological use is not without its disadvantages. Side effects can be extreme depending on the child (Montague & Warger, 1997; Jackson & Peters, 2008). Secondly, in a 1993 study Swanson et al. reported that placebo effect does contribute to perceived changes. Therefore, it is important to continue searching for interventions outside of pharmacological treatments.

Time for New Interventions

Educational desideratum revisited. ADHD interventions expand yearly, as insight is gained on its subtypes, biomarkers, and neurobehavioral status. Nevertheless, flaws remain in all four major current interventions, and therefore new interventions are warranted. Self-interventions seek to include the child in treatment, yet since it is child-initiated, performance is irregular. In educational settings, large class sizes and lack of teacher training exacerbate the ineffectiveness of child-led interaction.

Parental interventions aid in reducing symptoms (Reid, 1999), yet the majority of children spend six to seven hours a day away from home in public institutions. Classroom interventions have shown to be effective (Montague & Warger, 1997), but lack of teacher knowledge, high student-teacher ratios, and teacher misperception concerning ADHD (Perold, 2010) leaves interventions inconsistent. Pharmacological interventions have been shown to increase attention and decrease hyperactivity (Montague & Warger, 1997), yet not without side effects. Furthermore, stimulants are costly, and their acceptance and public perception is low (Jackson & Peters, 2008).

New interventions warranted in educational settings. A primary area of behavioral difficulty is the classroom setting. Since a large portion of an ADHD child's day is spent in a classroom setting, scales such as the Vanderbilt Scale (Wolraich et al., 1998) are available for teachers and school counselors. Workers in educational settings assess a child's severity of symptoms, the duration of symptoms, the variability of symptoms, and the possibility of comorbid disorders. Comorbid disorders like learning disorders and emotional/behavioral disorders (McKinney, Montague, & Hocutt, 1993) lead to varied educational accommodations. ADHD awareness is an extra responsibility of classroom teachers who must also attend to national testing, state standards, classroom management, parent communication, and diversified instruction. The lack of understanding by teachers concerning ADHD (Perold, 2010) is understandable.

Effects of ADHD in educational settings. Teacher understanding aside, ADHD negatively affects mental, social, and emotional status of 3 to 10% of children nationally ([APA], 1994; Barkley, 1997; Mattox & Harder, 2007) and greatly changes classroom dynamics. Low academic performance is well documented (Frick & Lahey, 1991; Nikolas & Burt, 2010; Monastra et al., 2002; Reid 1999) and cognitive control is becoming further understood (Randall et al. 2009). Comorbid disorders like learning disabilities rightfully explain low academic performance, but several inattention and hyperactivity symptoms are also to blame. Current educational methodology encourages seat time as a means of learning, yet ADHD children thrive on movement and novelty of tasks (Lahey et al., 1988; Montague & Warger, 1997). In addition, attentional bias mentioned by Zentall (1993) might be a culprit of low academic performance. Children potentially could deem certain classroom work or routines monotonous or boring therefore increasing inattention.

Cognitive control or executive functions (EF) discussed by Randall et al. (2008) within a classroom setting is an area of needed research. EF are "cognitive processes such as planning and implementation of performance strategies, the initiation and discontinuation of behaviors or actions, the inhibition of habitual responses or distracting information, monitoring of one's performance, sustained-attention and set shifting" (Castellanos et al., 2006, p. 119). Nigg (2006) classifies these functions into three theoretical categories of control, working memory, and activation. With numerous classroom tasks relying on multiple steps (e.g. math problems, writing prompts, group projects), increased "pod or group" work, and technology in the classroom, it is obvious that EF is consistently needed by children. Knowing that sustained-attention ability is imperative to EF, this study seeks to determine whether sustained-attention ability increases following outdoor play. If sustained-attention increases, it could be that EF also increases, thus enabling greater academic and social performance.

Furthermore, inattention and impulsivity/hyperactivity symptoms cause frequent classroom disruptions (Montague & Warner, 1997), perpetuating negative feedback from teachers (Montague & Warner 1997; Whalen et al., 1980) and peers, leaving many ADHD children rejected by social groups (McKinney, Montague, & Hocutt, 1993). Low self-esteem, a natural by-product of rejection (Weiss et al., 1978),promotes aggressive and antisocial cycles (Hinshaw, 1987; Johnston et al., 1985). This feedback loop fuels delinquent behaviors, aggression towards peers, and a tendency towards property destruction (Montague & Warner, 1997). Likewise, Ekins, McGue, and Iacono (2007) noted that low self-esteem in ADHD children contributes to later substance abuse. Low self-esteem stemming from negative parent feedback is of proportionate concern (Barkley, 1989).

While inattention and hyperactivity cause great concern in educational settings, the associated problems of cognitive control and executive functioning; low academic performance poor social skills and self-esteem; and aggressive/antisocial behaviors present an equal burden. It is vital that new interventions reach beyond stimulant use and help alleviate these associated problems. When searching for new interventions, nature is a plausible choice.

Nature: a historical educational intervention. History has shown that humanity often returns to nature for healing. Child educators, such as Reggio Emilia have long seen the environment as the third teacher of the child (Branzi, 1998). As early as the seventeenth century, Harvard educator, Louis Agassiz, postulated that nature study was imperative to child development (Lurie, 1988). Dewey considered nature an "essential educational vehicle" (cited in Moore, 1997, p. 205). Montessori recognized the need for nature study and the prepared environment for teacher and student alike. Likewise, Montessori suggested that nature study within a learning community is an essential agent of healthy child development (Montessori, 1966).

Edith Cobb in the *Ecology of Imagination of Childhood* stated that the greatest point of human potential found its roots within the child's relationship to nature (1959). Today's researchers recognize the health benefits of daily nature experiences (Moore, 1997). Kellert (2005) and Faber Taylor and Kuo (2006) express nature's association to physical, emotional and cognitive health.

As we forge new territory to better aid ADHD children in modern society we must consider nature as plausible ADHD intervention, especially in educational settings (Figure 4). Upon reviewing nature's affordances, it is hypothesized that time spent in nature has the ability to increase sustained-attention and decrease hypervigilance with the same vigor as our current best educational practices.

Nature: A Plausible ADHD prevention

Nature: appreciated by children. Nature is an obvious choice for an educational intervention, because children already enjoy it. Francis (1995) and Whiren's (1995) work on children's connections to gardens has given insight into vegetation and childhood experience. Francis (1995) notes that naturalistic spaces provide a place of mystery where copious activity occurs. Children appreciate nature whether it is partnered with physical play, pretend play, game play, investigations, or passive interactions (Whiren, 1995).

In addition, neighborhood playgrounds are childhood environments of attachment. Few parks are vast enoughto carry a variety of affordances (e.g., places to hide, jump, crawl, places of vegetation, places of beauty), whereas research shows children prefer more than two affordances are loved by children (Bjorklid & Nordstrom, 2007; Castonguay & Jutras, 2010). Children connect to natural spaces that are tidy, colorful, and teeming with flora and fauna (Loebach & Gilland, 2010).

Thirdly, a child's aesthetic preference often leads to visual exploration, which fuels curiosity and problem-solving (Bjorklid & Nordstrom, 2007; Castonguay & Jutras, 2010). Fourthly, large group activities and a range of social interactions emerge within park settings that provide ample affordances. This place of rich stimulation allows for independent mobility, action, social interactions, safety, and continuity (Chawla, 2002; Haikkola et al., 2007). While children love free play in nature, it is also vital to children's cognitive, physical, and social development ([APA], 2007).

Recess: loved by children. While it is evident that neighborhood park settings are vital to child development, it is easily seen that recess or outdoor play within the school day is equally important. Filled with running through grass, sandbox creations, memorized games with friends, curiosity about how high a swing will go, and little adult input, recess could be called a childhood Eden. Powell agrees that this Eden might have a hidden curriculum as well (2007). Recess within the Montessori school that Powell studied used the prepared environment with physical constructs to create social constructs. Primarily completed through fort play, friendships and community formed, which enabled self-esteem to flourish (2007).

Trudeau and Shephard (2008) confirmed this work in a traditional recess setting. In addition, free physical activity or play between twenty to sixty minutes in length aids in concentration and memory (Trudeau & Shephard, 2008) and even recess blocks as minimal as fifteen minutes a day increase classroom behavioral scores (Barros, Silver, & Stein, 2010).

Green playscapes: preferred by children. The literature on school playgrounds with vegetation or green playscapes demonstrates impact of those spaces on child development, and generates additional insight to nature's health benefits to children (Cobb, 1970; Dyment & Bell, 2008; Fjort, 2001; Harrington, 2008; Shulman & Peters, 2008). Shulman and Peters (2008) reported that sixty-eight percent of school properties in three major cities are designated for playscapes, but only ten percent of those playscapes have tree canopies. Yet, natural green playscapes are preferred by children (Dyment & Bell, 2008) and have greater affordances for play (Chawla, 2002). Playscapes with increased vegetation perpetuate motor fitness (Dyment & Bell, 2008) as well as coordination and agility (Fjort, 2011). Children participating in green playscapes experience less illness (Fjort, 2001; Dyment & Bell, 2008), have improved cognition (Cobb, 1970; Harrington, 2008), and enjoy healthier social interactions (Harrington, 2008).

Within green playscapes, the opportunity for outside green play, allows the repertoire of play to increase with vegetation, due to fact that naturally structured environments perpetuate participation across ages and genders (Bell & Dyment, 2008). The presence of varying tasks within green play optimizes novelty and curbs boredom (Harrington, 2008). Play within these constructs is variable in intensity, which contributes to collaboration rather than competition, aiding in the formation of positive peer interactions and social development (Harrington, 2008).

Since green play improves cognition (Cobb, 1970; Harrington, 2008), it could be a valuable resource to school institutions, especially for ADHD children who are in need of increased stimulus and variety of environment (Zentall, 1993). As a child experiences grass rubbing on their shoelaces, falling leaves, a well-worn trail, a favorite hiding spot, ladybugs landing on their arm, a child-constructed forts, or a bird chasing foil covered juice boxes, informal learning resides. This type of unscripted learning is rich with environmental awareness, curiosity, observation, and reasoning (Cobb, 1997; Herrington, 2008), the exact skills teachers aim to teach within classroom walls, and the exact learning that benefits ADHD children since it improves sustained-attention by expanding selected-attention tasks (Zentall, 1993).

Not only is green play beneficial to children's health and cognition, it is preferred by children and teachers. A recent study notes that playgrounds with vegetation and multisensory components are preferred by teachers because teachers perceive that within these green playscapes, gross motor activity is increased (Herrington, 2008). Similar to traditional classroom educators, day care workers prefer environments that are rich in complexity and exploration balanced with safety and restoration for young children (Tranick & Evans, 1995). If green play improves cognition in children and is preferred by children and teachers alike in both younger and upper grades, it could be an easy intervention or possibly even preventative to ADHD children's symptoms of lack of sustained-attention and increased hypervigilance.

Nature's affordance and current ADHD interventions. Since current educational interventions attempt to meet ADHD students' needs in the classroom, this study seeks to determine whether nature's affordances could be used as an alternative intervention (Figure 2). The affordances of nature are well documented, and the current interventions are well-documented. With respect to the current study, it is wondered if the affordances documented could alternatively become interventions specifically for sustained-attention and hypervigilance regulation.

Current Known Benefits of Nature

Humans' connection to nature. The relatively new field of ecopsychology brings further understanding into humans' longing to connect to nature and gain well-being from the environment (Berger & Mcleod, 2006; Mayer, Frantz, Brehlman-Senecal & Dolliver, 2008). "Nature is a live and dynamic environment that is not under the control or ownership of a therapist…and is an open independent space, which has existed before their arrival in it and will remain long after they depart from it" (Berger, 2003, p. 82). Kellert (1997) notes that the biophilia hypothesis suggests that humans need to feel connected to nature. Mayer et al. (1983) study revealed that a human's relationship to nature cultivates greater connectedness, positive emotions, and ability to reflect on life's hindrances. Other research suggests that nature optimizes social contact, child development, sense of purpose, exercise, and attention (Ulrich, 1983). Conversely, nature reduces stress (Ulrich, 1983).

Ulrich's (1983) conclusion that natural environments benefit adults physically, cognitively, and emotionally suggests that nature supports human development like no other medium. Nature settings are multi-sensory spaces evoking informal play, thus promoting imagination, creativity, neurological development and self-esteem (Cobb, 1997). Nature affords primary experience, a diminishing trait, in a culture of increased Facebook interactions, "gaming", and smart phone communication. In a culture of media-saturation and 24/7 technological access, nature has the ability to rejuvenate. This unique rejuvenation extends from not only humans as individuals, but also human culture (Rivkin, 1995). Secondly, as biological beings, humans evolve through experiencing stimuli that provoke change, in order to meet the demands of an environment (Chawla, 2002; Moore, 1997). At its essence, nature is a multi-sensory non-judgmental space in which the humans have the ability to seek change (Rivkin, 1995).

Figure 2. Current Educational Practices vs. Natures Affordances

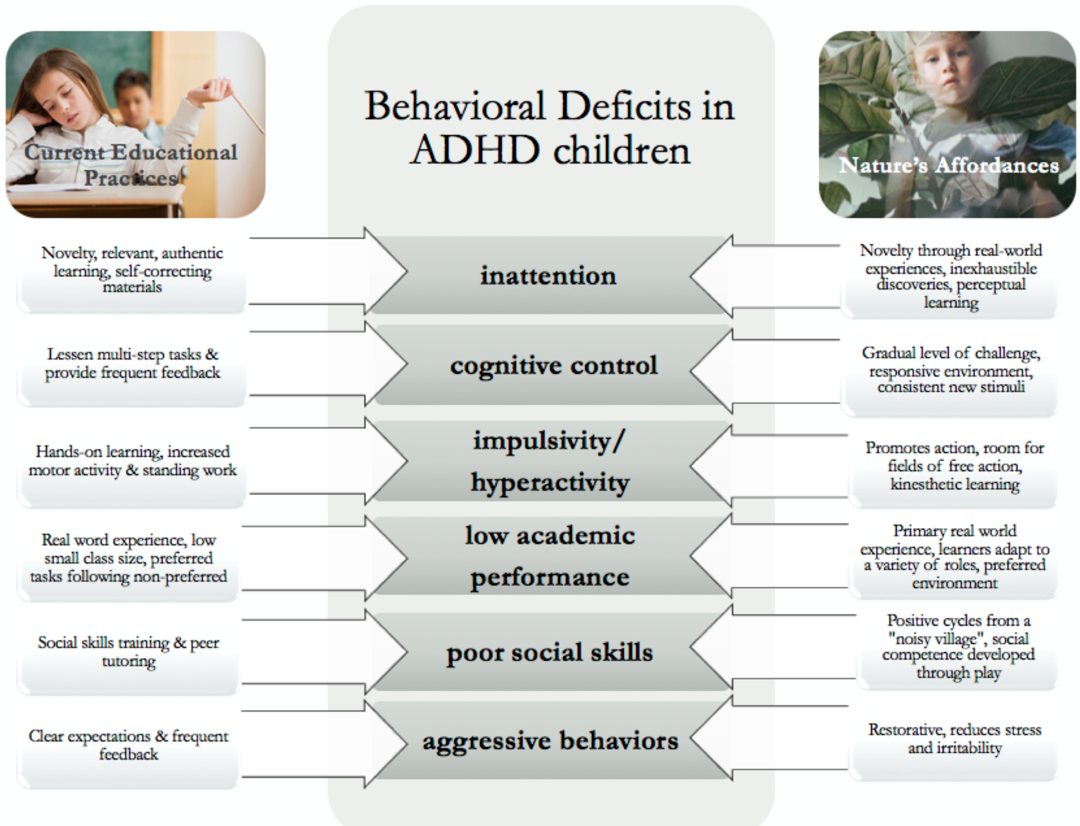

Figure 2. Current educational practices used to defuse ADHD symptoms in educational settings, aligned with nature's affordances drawn from the findings of Bjorkld & Nordstrom, 2007; Castonguay & Jutras 2010; Chawla, 2002; Cobb 1977; Dyment & Bell, 2008; Fjort, 2001; Haikkola et al., 2007; Harrington, 2008.

Nature as therapy. There is a growing body of knowledge of nature being used as a therapeutic setting in both adventure-based and wilderness-based programs (Peel & Richard, 2005). Adventure therapy is clients and therapists participating in high adventure activities like rock-climbing, kayaking, and high ropes courses in order to facilitate psychotherapy (Peel & Richard, 2005). As participants engage in natural high adventure settings outside their everyday experience, they are pushed physically, emotionally, and mentally, thus creating pliability and adaptation. Garst, Scheider, and Baker (2001) have contributed empirical data to the conversation by examining the role of outdoor adventure trips on self-perception. Results suggest that the behavioral conduct changed in the in the participants directly following outdoor adventure trips, deeming the experience highly therapeutic.

While adventure and wilderness therapy have been primarily practiced with adult and adolescent populations with behavioral or boundary difficulties, nature therapy has also been used with children under twelve years old (Berger, 2006). Nature therapy is a unique approach where client and therapist are partners with the environment in order promote healing (Berger, 2003; Berger 2004; Berger, 2005). Berger and Mcleod (2006) have derived a framework for nature therapy through extensive work with children in Israel. The framework includes the use of nature as the therapeutic setting, incorporating it into ritual and using it to connect children to their body, spirit, and mind. Through this framework, they have noted that the aesthetics of a child's outdoor environment significantly influences their emotions and peer interactions.

In a 2006 case study, Berger extended the nature therapy framework to children with learning disabilities. In a yearlong program, children with a low IQ in a school setting were guided through seasonal rituals. They built homes in nature to encourage a nature connection, and spent extended recess time in a school garden. Employing grounded theory, the researcher found that nature had a central role in the therapeutic process. The strongest implication was that therapist, teacher, or child could not control the constantly changing environment. The dynamic environmental setting caused children to cope, to deal with the unexpected, and to develop flexibility. These skills were later transferred to the classroom setting and home life.

In the same year that children in Israel were learning how to cope with stress, urban public school teachers on the other side of the world were asked to evaluate how they cope with stress (Gulwadi, 2006). Stress, according to Gulwadi, is "when people encounter environmental demands that overwhelm personal resources" (2006, p. 506). One copes with stress through two strategies: change of self or change of environment (Lazarus & Launier, 1978). Therefore, Gulwadi's (2006) findings that teachers often use nature or kinesthetic activity to cope with school-related stress renders insight into children's preferences in dealing with school-related stressors.

If nature therapy is already being used as a therapeutic process for children and if teachers are already using as a way to cope with school-related stressors, could this same intervention be applied to children with ADHD? Knowing that ADHD children's under-aroused brains become stressed by the sustained-attention tasks required of them in educational settings, could nature become a therapeutic school day intervention for increasing their attention? Additionally, since teachers use kinesthetic activity to reduce personal stress, could they use the same type of motor activity through outdoor play as a way of decreasing hypervigilance in their students?

Nature as restorative force. Gulwadi's (2006) work was ground in the work of Kaplan and Kaplan (1989). Beginning in wilderness settings, Kaplan and Kaplan pioneered attention restoration theory (ART) allowing others to induce and classify certain environments as rejuvenating or restorative (Cole & Hall, 2010; Kaplan, 2001). ART is composed of four elements:

being away: being distinct, either physically or conceptually, from the everyday

> environment; fascination: containing patterns, that hold one's attention effortlessly; extent: having scope and coherence that allow one to remain engaged; and compatibility: fitting with and supporting what one wants or is inclined to do (Kaplan, 2001, p.481).

Within ART there are two sub-types of attention: directed or involuntary (James, 1892; Kaplan, 2001). Directed-attention is attention that determines the central focus of task. This type of attention fights extraneous stimuli and prioritizes tasks. Effortful and deliberate tasks and situations require directed-attention, which can lead to fatigue of mental capabilities with time. Directed-attention is therefore a "precious and fragile resource" (Kaplan, 2001, p. 485). For direction-attention to be restored, involuntary attention must be given preference.

Involuntary attention is "automatic rather than intentional" (Kaplan, 2001, p.486). An individual's involuntary attention is drawn to settings that embody elements of being away, fascination, extent, and compatibility, deeming them restorative. Restorative environments are absorbing to the mind and allow cognitive rest. They have unique objects and materials, are aesthetically pleasing (i.e., design is present with bright pleasing colors and sights), and have increased stimuli (e.g., moving parts, animals, sounds, smells) (Cole & Hall, 2010; Han, 2009; Kaplan & Kaplan, 1989; Kaplan 2001; Mayer et al., 2008).

Restorative environments also reduce mental stress (Cole & Hall, 2010; Gulwaldi, 2006; Ulrich, Dimberg, & Driver, 1991), facilitate emotional regulation (Berger, 2006; Korpela et al., 1991), and restore attentional capacity (Cole & Hall, 2010; Kaplan & Kaplan, 1989; Kaplan, 2001). Whether it is a favorite place (e.g. Starbucks or grandma's house), a natural space (e.g. Yosemite Valley or an office with a window), or a kinesthetic activity (e.g. jogging or yoga class) these restorative environments evoke emotion (Berger, 2006; Cole & Hall, 2010; Gulawldi, 2006; Han 2010; Kaplan & Kaplan, 1989).

Wilderness settings in particular have been rated restorative to various populations. No matter the length of exposure or the amount of congestion present, nature restores attention and reduces stress among recreational backpackers (Cole & Hall, 2010), but nature's ability to restore attention in ADD or ADHD children is a newer area of study.

Nature and ADHD

EEG vigilance regulation through melatonin and Solar Intensity treatments. One aspect of nature that warrants further study is the use of light therapy (LT) and its effect on ADHD pathology. LT is generally defined as 30 minutes in natural light of 5,000- 10,000 lux (Burgess 2011; Ryback et. al., 2006). Rybak et al. (2006) treated ADHD adults with LT for 3 weeks, rather than melatonin, and reported improvements on the Brown Adult ADD scale and neuropsychological measures (e.g. CPT, Wisconsin Card Sorting Test) with medium effect sizes.

Likewise, a study on children who received melatonin treatments for 2-3 years showed both behavioral and emotional mood improvements, and a discontinuation showed a relapse of SOI (Hoebert et al., 2009). These studies suggest that both melatonin and/or LT can aid in normalizing SOI through promoting circadian phase delay in a sub-group of ADHD patients (Arns & Kenemans, 2012). DLMO is equally helpful in determining responses to LT (Cajochen et al., 2005). Since ADHD is most often diagnosed after the age of 5 or 6, and SOI is generally present before the age of 3, it is suggested that SOI is tied to an accumulated sleep-restriction that ultimately develops into unstable EEG vigilance regulation (Arns & Kenemans, 2012; Beebe et al, 2010). Impaired EEG vigilance regulation (Sander et al., 2010) overlaps with what is sometimes referred to as 'under-arousal' or 'cortical hypo-arousal' (Clarke et al., 2011).

Arns et al. (2013) assessed ADHD prevalence (PREV) and Solar Intensity (SI: kWh/m2/day) based on PREV estimates in children from the CDC per US state (Visser et al., 2010), and PREV estimates from several countries (Fayyad et al., 2007). For the United States data, the US National Renewable Energy Laboratory's (NREL) radiation model was used to assess hourly satellite imagery, daily snow cover data, and monthly atmospheric water vapor, trace gases, and atmospheric aerosol averages to calculate the hourly total insolation on a given horizontal surface (Perez et al., 2002). A correlation was then calculated between PREV and SI, and potential confounding variables were obtained. Variables significantly correlated with PREV (e.g. average income, latitude, infant mortality) were accounted as control variables through partial correlation analyses. A sigmoidal dose-response relation was deduced ($p<0.0006$; $F=13.78$; $R2=0.36$; $DF=1,46$ | $p<0.0002$; $F=16.38$; $R2=0.37$; $DF=1,46$), and a linear fit resulted following a log transformation of PREV and SI with significant correlation between PREV and SI ($p<0.002$; $r=-0.429$ | $p<0.004$; $r=-0.409$; $DF=49$). The analysis was then re-examined as monthly data for SI, to guarantee that the correlation was not moderated by seasonal fluctuations. Monthly SI did not influence the PREV and SI association. Therefore, the study suggests that there is a clear relationship between SI and PREV, and that SI could be a plausible ADHD preventative.

Likewise, the study suggested that while there are a variety of hypotheses concerning the SI/PREV association (e.g. vitamin D deficiencies) (Tolppanen et al., 2012), SOI should be a valuable next research area. Recent studies have shown that increased use of social media devices close to sleep-onset results in delayed sleep (Custers & Van den Bulck, 2012; Van den

Bulck, 2004), reduced sleep duration (Van den Bulck 2012), and melatonin suppression (Cajochen et al., 2011; Wood et al., 2012). Modernity has caused increased “screen time” , with the introduction of tablet devices, LED computer screens, and mobile phones,; subsequently, the light intensity and proximity of media to occipital receptors has increased significantly over the past 10-15 years (Arns et al., 2013). Blue light, specifically, emitted from modern media devices been shown to affect photosensitive melanopsin receptors, thus affecting suprachiasmatic nuclei, which act as a circadian pacemaker. Therefore Arns et al. (2013), hypothesized that preventive SI, resulting from intense morning natural light, counteracts the effects of latter day media use, which would generally delay sleep and reduce duration.

As stated by Arns et al. (2013), controlled studies, specifically investigating morning light exposure or reduced blue light exposure in evening hours, need to be procured. This type of research could encourage prevention of a subgroup of ADHD children through exposing children to increased natural light throughout the waking hours (by increased outdoor play time in the school day or construction of solar tubes in our nation's classrooms), increased parental controls on time spent on media devices, or manufacturing restrictions on types of light emitted by mobile devices during certain times of day (Arns et al., 2013). Additionally, could exposure to early morning bright light in educational settings therapeutically help ADHD children through reversing SOI and increasing sustained-attention?

Sustained-attention increased through green play treatments. Faber-Taylor, Kuo & Sullivan’s 2001 national online survey of 450 participants recognized that parents perceive significant reductions in their child’s ADHD symptoms of decreased sustained-attention and increased hypervigilance following activities in green play environments. Building upon this survey, Faber-Taylor & Kuo (2004) used ART as theoretical framework, to assess green play environments' ability to restore attention. The 2004 study attempted to quantify the 2001 national study by determining whether the attention improvements concluded in the online survey were verifiable by setting "controlled exposures to different settings and measuring attention objectively" (p. 403).

The final sample included seventeen children, fifteen boys and two girls all in the age range of 7 to 12 years old. Sixteen of the children's parents completed pre-surveys. Six of the sixteen were diagnosed with ADD and ten with ADHD. All of the children did not receive pharmacological interventions the day of the green play treatment. Treatments were composed of three differing walks (one per week), each in a varied setting: park setting, urban-setting, and neighborhood setting. Each setting had comparable terrain, noise level, and traffic. All three routes contained well-maintained paths or sidewalks. The same leader guided the walks each week for twenty minutes, and children were encouraged to refrain from conversing on the walk.

Prior to the walk students were given various puzzles aiding directed attention fatigue. After the treatment, children completed a Digit Span Backwards test (DSB) (Faber-Taylor & Kuo, 2004). Then children were asked to assess their walk (using a 3-point Likert-type scale) to determine if they perceived the walk as "fun, relaxing, interesting, scary, boring, weird, and/or uncomfortable" (Faber-Taylor & Kuo, 2004, p. 404). The study was an improved attempt at quantifying the restorative cognitive benefits of the previous online study, and the results were statistically significant. In comparison to DSB tests completed by children using pharmacological interventions, walks in the park delivered comparable results.

As mentioned in the Faber-Taylor & Kuo's (2004) discussion, however, without a latter assessment of attention ability later in the evening, it is unjustified to consider "walks in the park" a lasting ADHD treatment. Further study on the longevity of attention ability following a green play treatment needs to be formulated before doses of nature can be deemed a medicine. As well, nature's effect on ADHD symptoms beyond inattention needs to be analyzed. Analysis of both sustained-attention and EEG vigilance regulation are imperative for determining behavioral changes following green play treatments. Additionally, the uses of both behavioral and neurological measures are needed to understand the mechanisms within ART. A greater understanding of environments that children perceive as restorative also seems crucial for associating behaviors with specific settings or environments.

Purpose of this Study

Using attention restoration theory (ART) (Kaplan & Kaplan, 1989) as a theoretical framework, this study will seek to explore the neurobehavioral benefits of green play on sustained-attention in ADHD children. Children diagnosed with ADHD struggle with hypervigilance/ hyperactivity and sustained-attention. Symptoms of hyperactivity are fidgeting, over-talking, wiggling, and moving quickly from one stimulus to another (Lahey et al. 1988; Montague & Warger, 1997). Likewise, instead of being able to concentrate on attention based tasks ADHD children often have attentional bias and choose to only focus on tasks that they deem engaging (Montague & Warger, 1997). ART has shown to aid in restoring attention in non-ADHD adults and children (Cole & Hall, 2010; Kaplan & Kaplan, 1989; Kaplan, 2001). Preliminary studies have relied on ART to understand attention restoration through green play environments with ADD & ADHD children (Faber-Taylor & Kuo, 2001; 2004). However, neither Faber-Taylor & Kuo's 2001 or 2004 study used a neurobehavioral measure to aid in quantifying sustained-attention or hypervigilance regulation. It is hypothesized that 30 minutes of green play will positively affect children's sustained-attention and hypervigilance regulation.

One abiotic factor, Solar Intensity (SI) has also been an area of study in neuroscience and ADHD adults. Research suggests that increased SI through light therapy (LT) aids in EEG vigilance regulation (Ryback et. al., 2006). Therefore, SI will be an environmental abiotic factor that will also be measured during the study to be used in later analysis.

CHAPTER 3.

METHODOLOGY

This study used attention restoration theory (ART) as a framework and followed Faber Taylor and Kuo's (2004) study design by using a pre-measure followed by a thirty minute guided nature walk and a post-measure (Kaplan, 1999). The sample consisted of eleven children ages 7-13 years old, all diagnosed with ADHD. The pre-measure included a neurological EEG scan. The post-measures included an EEG scan, Continuous Performance Test (CPT) (Rosvold et al., 1956) and a modified Perceived Restorative Scale (PRS-11) (Pasini, Berto, Brondino, Hall, & Ortner, 2014). All methods and instruments were proposed and approved by the Montreat College IRB in December 2014.

Population & Sample Size

ADHD children ages 7-13 years, diagnosed using the DSM-IV or DSM-V were chosen for this study (n=11). Parents in the community were notified about the study in several ways: letters from the local elementary school's 405 plan and Individualized Education Plan (IEP) coordinator were sent to parents who had students that were identified with ADHD; notifications to parents were posted social media networks, such as homeschool forums; flyers were posted at local counseling offices, neurofeedback offices, pediatricians offices, and local Black Mountain/Asheville businesses. The notices in all three locations explained that a study was being conducted to help aid educators and parents in understanding the role that green play environments have on ADHD symptoms. Parents were directed to a website, www.greenplay-adhd.com. There, they could register their child online, download consent forms (Appendix A), and receive information about the researcher and institution. The consent forms detailed the methods of the study and confidentiality of the experiment. One child's data was partially lost due to a technical error. Therefore, a total of ten subjects were analyzed completely.

Green Play Treatment

The treatment day was a weekend morning in order to not disturb the student's school schedule. On the day of the treatment children did not take their morning pharmacological interventions, but instead took it following the green play treatment so that children's pre-EEG scans could be viewed at a resting state without pharmacological influence. It has been shown that children on pharmacological interventions such as a methylphenidate have decreased errors and decreased impulsivity and hyperactivity on CPTs ((Michael, Klorman, Salzman, Borgstedt, & Dainer, 1981). Administration of pharmacological intervention was the role of the parent(s) following the study. Children were scheduled to arrive at forty-five minute to one-hour intervals throughout the morning, with up to four children participating in the study at a time. Once arriving at the location, parents were given a confidential background survey about the child's age, how the child was diagnosed, their pharmacological interventions or lack thereof, normal pattern of outdoor play or lack thereof, school difficulties or lack thereof (Appendix B).

Due to children's summer schedules, three separate testing days were provided. Each day was recorded as a separate cell. There were up to one to three groups per cell, and each group had at least two children present (Figure 3). Cell 1 had two groups present with three children in the first group and two children in the second. Cell 2 and Cell 3 both had one group present with three children in each group. All testing was performed in the same sequence for each cell and group.

Figure 3. Schedule of Children's Testing Cells and Groups

	Group 1		Group 2
9:00am	Scan *(leader A, B, C, D)*	10:00am	Scan *(leader A, B, C, D)*
9:30am	Walk *(leader E)*	10:30am	Walk *(leader E)*
10:00am	Scan *(leader A, B, C, D)*	11:00am	Scan *(leader A, B, C, D)*
10:20am	CPT & PRS *(leader F, G, H, I)*	11:20am	CPT & PRS *(leader F, G, H, I)*
10:45am	Group 1 leaves	11:45am	Group 2 leaves

	Group 3
11:00am	Scan *(leader A, B, C, D)*
11:30am	Walk *(leader E)*
12:00pm	Scan *(leader A, B, C, D)*
12:20pm	CPT & PRS *(leader F, G, H, I)*
12:45pm	Group 3 leaves

Figure 3. Schedule of children's planned groups. Due to low recruitment, most groups were not at full capacity.

On the testing dates the first children in Group 1 (G1) arrived at 9:00am and were given electroencephalography (EEG) scans in order to measure their sustained-attention and EEG vigilance regulation ability. Subsequent groups ran their scans at 1 hour, or 45-minute intervals depending on the cell day (Figure 5). Using a 14-source electrode location EEG helmet by *Emotiv*, EEG scans were conducted to measure the electrical impulses along the child's scalp in wavelets. A total of 14 channels were recorded: F7, AF3, AF4, F8, F3, F4, FC5, FC6, T7, T8, P7, P8, O1, and O2.

The ratio of theta/beta (TBR) waves present in a child at a given time helped determine their EEG vigilance regulation ability and sustained-attention (Arns, Conner, & Kraemer, 2012). Increased absolute power in theta bands has been reported in ADHD children (Arns et al., 2011). Evidence of low beta being a characteristic of ADHD children has been supported (Loo & Makeig, 2012; Matsuura et al., 1993). However, there is also a subtype of ADHD children with high beta attributes, which include symptoms of alertness and agitation (Clark et al., 2001). It is important to note that I hypothesized that beta will increase following green play, and that in the case of ADHD child already has a high beta frequency green play could possibly cause agitation. Scans were operated simultaneously by up to three EEG operators in one large open room for 47 to 100 seconds at a time. Operators were asked to try to record 90 seconds scans. However, due to poor connectivity several scans were shorter. Children participated in three scans both pre and post. During the first scan, student's eyes remained open while staring at a white wall. Then, they completed an eyes closed scan. Last, they had a scan while looking around the room (Loo & Makeig, 2012; Monastra, et al., 1999). The three scans were then repeated following the children's green play intervention.

Environmental Settings

Following their three pre-scans, students were led on a moderately- paced walk by a trained outdoor educator for 30 minutes. The green play environment chosen for the study was the Montreat/Black Mountain Greenway, a pathway in Montreat, North Carolina. The trail traverses Flat Creek, has ample vegetation, and varies from rocky dirt paths to asphalt. The pathway also crosses the Montreat College campus where the scans occurred, which meant children could immediately enter the treatment area following their pre-scans. Children were instructed to keep talking to a minimum (Faber-Taylor & Kuo, 2004) in order to remove the socialization variable of the task. However, the outdoor educator who guided the walk reported that several children talked to themselves throughout the walk. Solar Intensity (SI) was recorded using the Pyle PLMT56 Light Meter in order to document lux at 15-second intervals during the walk. The SI was aggregated using a weighted mean. Documenting the SI allowed for consideration of lumen intensity on EEG vigilance regulation and/or sustained-attention if the PRS-11 did not show that the environment in and of itself was restorative to the children.

Post-Tests and Analysis

Neurological measure: post-EEG scans. Following the treatment, students returned to the testing room for three post-EEG scans. The scans were operated by the same trained operators from their pre-scan, and mimicked the methods of the pre-scan. The post-scans measured the child's TBR post-green play, and were analyzed to measure change in

Figure 4. Modified Perceived Restorative Scale (PRS-II)

Proctors asked the subjects the eleven questions as follows:

1. Places like that are fascinating
2. In places like this my attention is drawn to many interesting things
3. In places like this it is hard to be bored
4. Places like that are a refuge from problems/annoyances
5. To get away from things that usually demand my attention I like to go to places like this
6. To stop thinking about the things that I must get done I like to go to places like this
7. There is a clear order and pattern to places like this
8. In places like this it is easy to see how things are organized
9. In places like this everything seems to have its proper place
10. That place is large enough to allow me to explore in many directions
11. In places like that there are few boundaries to limit me from moving about

Figure 4. ADHD children were asked orally about their experience in the green play environment and their answers were recorded using a 7-point Likert scale. The PRS-II was developed by Pasini, Berto, Brondino, Hall, and Ortner (2014).

TBR, which is an indicator of children's sustained-attention and vigilance regulation. A decrease in TBR would support the hypothesis that following a green play environment, ADHD children have greater ability to regulate their vigilance and greater ability to concentrate on sustained-attention tasks. This heightened vigilance regulation aids in decreasing hyperactive behaviors (Arns & Kenemans, 2011). Increases in the TBR would suggest that green play does not have a significant effect on vigilance regulation and that other treatments should be pursued, or that the experiment lacked in adequate measurement to detect change in TBR.

Behavioral measure: post–continuous performance test. After post-EEG scans, ADHD children were given a Continuous Performance Test (CPT) (Rosvold et al., 1956) administered online by Millisecond.com to determine a behavioral measure post-walk (Draine, 2015). "The Continuous Performance Tests **(**CPT) is a measure of vigilance or sustained-attention or attention over time" (Gualtieri, 2005, p. 22). Poor performance on the CPT has been reported for children diagnosed with ADHD or learning disabilities because it is indicator of central nervous system (CNS) dysfunction in general, and is not specific to any particular condition (Gualtieri, 2005). The CPT was administered through a computer monitor with a white screen. Children had two active sessions each 5 minutes in length with a 2-minute resting session in between. The first session was composed of 31 distractor letters with 8 target letters (X) appearing on the screen. The instructions by Millisecond Inc., given before the first session, stated,

> Welcome to the Continuous Performance Test. When the test starts, you will see letters appearing one at a time. Your task is to press the spacebar key every time you see an X, and only when you see an X. If any other letter appears on the

> screen, simply wait for the next letter to appear without pressing any keys. Press the spacebar now to continue (2012).

As the children participated in the first session, Millisecond Inc. was recording their omission errors, the X targets that they were not responding to (i.e. "hits"), and their commission errors, the distractor letters that they were responding to (i.e., "misses"). Omission errors are stated to measure sustained-attention and commission-errors are stated to measure hyperactivity/impulsivity (Gualtieri, 2005). Following Session One, children were given their 2-minute resting break, and then began Session Two with the AX-test. In the AX-test, the letters are presented one at a time, as a series of cue-target pairs. The object of the task is to respond, but only when X (target), is following the A (cue). This requires the subject to remember that A is not the target, but instead the cue. Before the second session, the children were given these instructions:

> Your next task is again to press the spacebar key whenever you see an X, but this time only if the X follows right after the letter A. That is, press the spacebar if and only if you see an X presented immediately after the letter A. Whenever you see the letter A, get set; if an X comes right after it, press the spacebar. Press the spacebar now to continue (Millisecond, 2012).

As the children participated, Millisecond Inc. recorded their omission and commission errors, this time with an AX combination. Low omission scores support the idea that green play increases a child's sustained-attention and low commission scores support the idea that green play increases regulation of hypervigilance.

Children were not given the CPT before the walk because it is known that during CPT testing, scores inevitably worsen on the second set (Michael, Klorman, Salzman, Borgstedt, & Dainer, 1981). To alleviate this variable children were only given the CPT following the green play treatment, and then their scores were compared to norms for ADHD children taking a placebo, ADHD children taking Methylphenidate, and children not diagnosed with ADHD (Michael et al., 1981). The one difference in testing methodology between the Michael et al. (1981) groups (placebo, methylphenidate, and non-ADHD children) and the green play study was the number of letters present in the test. The green play group was given a CPT with 25 different distractor letters and the norms groups were given 5 to 6 distractor letters. While this difference in distractor letters did not seem significant when choosing a norm comparison group, it is noted here.

Post-perceived restorative scales. Next, children were asked orally about their perceptions of the green play environment using modified Perceived Restorative Scale (PRS-11) (Pasini, Berto, Brondino, Hall, & Ortner, 2014). While there is a Perceived Restorative Components Scale for Children (PRCS-Cii) (Bagot, 2004; Bagot, Kuo, & Allen, 2007), the PRS-II was chosen instead because it is half the length as the PRCS-Cii (Bagot, 2004; Bagot et al., 2007) and it is documented that ADHD children struggle to complete lengthy tests. The PRS-II (Pasini et al., 2014) uses ART as a theoretical framework and aids in quantifying the student’s perceptions of the environment using Kaplan’s four criteria of restoration: being away, fascination, extent, and compatibility (2001). The scale was administered orally and children answered a 7-point Likert scale to communicate (figure 4) the perceived restorative effect of the green play environment. Each proctor began the Perceived Restorative Scale with this statement:

We are interested in how you experienced the environment during your walk. To

> help us understand your experience, we have provided the following statements for you to respond to. As I read you the statements, ask yourself: "How much do these statements apply to my experience on the walk?" If you think that the statement does not apply to your experience of the environment, then you would tell me to circle "totally disagree", if you think it applies you would tell me to circle "totally agree". If you think it is somewhere in between, you can also say "disagree", "somewhat disagree", "agree" or "somewhat agree". If you are unsure, you can always say "undecided".

The PRS-II yielded a greater understanding of the perceived restorative effects of the Montreat Greenway, and helped to establish green play's effect on restoring sustained-attention and EEG vigilance regulation. If children did not deem the environment restorative, and sustained-attention and EEG vigilance increased, variables outside of Kaplan's (1989) model could be considered. One potential variable could be Solar Intensity.

Data Analysis

Analysis of pre-and post-EEG scans. Ten out of eleven EEG scans were analyzed by Dr. Onton, neuroscientist at Swartz Center for Computational Neuroscience at University of California San Diego. Using Artifact Subspace Reconstruction (ASR) in EEG lab the remaining ten datasets were cleaned to reduce extraneous non-stationary high variance signals (Kothe, 2013). The range of time of scans across subjects was between 47 to 101 seconds. The variability of time on the scans was caused by the subjects' ability to keep the headsets on or connected during the testing block. Power was calculated in 2 ways, "wavelet transform and Hilbert transform, and both yielded comparable results" (Onton, personal communication, August 11, 2015). Mean theta and mean beta was divided by time mean theta was then compared to mean beta power, creating the theta/beta ratio (TBR). The following calculations were performed to estimate TBR using four datasets: pre-eyes open, pre-eyes closed, post-eyes open, and post-eyes closed. The pre-ratio was subtracted from the post-ratio in both the eyes open and eyes closed conditions. The children's third scans of "looking around the room" were not analyzed at this time due to extraneous impulses that made scans difficult to interpret. Data was kept separate in order to recognize trends among each child's individual scans (Figure 5-6). Blank spaces on the figures represent channels that were absent in the subject either pre- or post- and therefore could not be compared (Table 1-2). These spaces were primarily caused by loss of connectivity from the *Emotiv* headsets to the child's scalp during the scan. However, one child also removed his headset during the post-scan and chose to not repeat the process.

Each of the fourteen channels was analyzed for two primary bands: theta (4-8Hz) and beta (13-30Hz). Due to beta's large range bands, it was originally analyzed three times using three different ranges [low beta (13-18Hz), midrange beta (18-25Hz), and high beta (20-30Hz)], however analysis was comparable and the range 13-18Hz was deemed the most representative for this population (Hamlin, personal communication, August 26, 2015; Onton, personal communication, August 11 and 24, 2015). Channels F4 and F8 were deemed most important to analyze because of their position in the frontal cortex, and their relationship to the amygdala. Both F4 and F8 are responsible for the brain's most complex processing including sustained-attention.

Analysis of continuous performance test. Since CPT scores, are positively correlated to age, the norms were split into three age categories: 5.9-8.5 years, 8.7-10.5 years and 10.6-13 years (Michael et al., 1981) and a mean. Scores from children in the green play study were then compared to children within their age category across the three norms and as a total treatment group.

In summary, this study used Kaplan's ART as a theoretical framework to further understand the role of green play environments on sustained-attention and hypervigilance ability in ADHD children. Using the Faber Taylor & Kuo's study design, students experienced a neurological measure pre- and post-, a behavioral measure post- that was compared to a norm group, and a restorative scale that measured the perceived restorative effect of the green play treatment. The neurological measure was a 14 channel EEG with eyes closed, eyes open and eyes looking around the room. The behavioral measure was a CPT (Rosvold et al., 1956) that was compared to a set of norms (Michael et al., 1981). The restorative measure was a modified perceived restorative scale (PRS-11) that had only eleven questions, and helped determine if the children found the environment restorative.

CHAPTER 4.

RESULTS

It was hypothesized that ADHD children would respond to green play treatment in three ways: 1) their EEG scans would show a decrease in theta/beta ratio (TBR) indicating that sustained-attention ability and hypervigilance regulation increased (Arns et al., 2001); 2) their Continuous Performance Tests (CPT) (Rosvold et al., 1956) would show less omission and commission errors than ADHD children taking a placebo (Michael, Klorman, Salzman, Borgstedt, & Dainer, 1981); and 3) that their Perceived Restorative Scales would give evidence to their natural affinity and perceived restorative effects of the green play environment (Bagot, 2004; Bagot, Kuo, & Allen, 2007). Evidence in support hypothesis 2 (H2) and hypothesis 3 (H3) was found, and numerous limitations concerning the method of recording theta/beta ratio (TBR) were documented.

Difference between Pre- & Post- TBR

The difference between TBR eyes open scans pre to post at the F8 channel was 3.54 +- 4.7 and the difference between TBR pre and post at the F4 channel was 1.22 +-3.7 when using the 13-18Hz beta range (Table 1). When using the same beta range, the difference between eyes closed scans pre to post at the F8 channel was 1.3 +- 2.8 and 1.57 +- 1.3 at the F4 channel (Table 2). When changing the beta band range to include the higher beta bands 13-25 or 20-30Hz the results show an even greater TBR increase across F4 & F8 channels (Figures 3 and 4). Additionally, the other channels seem to lack a pattern or consistent distribution. Homologous pairs (e.g. channels F7 and F8) do not seem to show normal pairing, and are out of sync. This ambiguity was present whether the beta band was analyzed at 13-18Hz, 13-25Hz or 20-30Hz.

Eyes closed scans seem to have a generalized increase across all channels when compared to eyes open scans. Visual “looking around” scans were not analyzed due to the fact that they were filled with peripheral impulses, making scans difficult to analyze. (Onton, personal communication, August 24, 2015). These positive increases from pre- to post- suggest that TBR increases after green play. This does not support the hypothesis (H1) that TBR will decrease following green play, and therefore reduce hypervigilance or increased sustained-attention. However, there are several confounding variables and study limitations addressed in the discussion that need to be explored to fully reject this hypothesis.

Table 1

Eyes Open Pre and Post difference of Theta Beta Ratio (TBR)

	EEG Channels													
Subject	AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
C1G2R1	-0.36	---	-1.67	---	---	---	---	---	---	-0.38	0.88	-1.47	0.43	0.43
C1G2R3	1.53	-0.48	0.98	0.67	---	---	---	---	---	0.20	1.26	0.27	---	0.12
C1G2R5	3.54	0.77	2.15	1.45	---	-2.50	-0.02	-0.13	---	-0.91	0.71	2.23	0.37	2.06
C1G3R7	1.20	---	0.40	0	---	---	---	---	---	0.68	1.28	1.14	---	1.93
C1G3R9	-0.49	-1.26	0.10	-1.21	---	---	---	---	---	---	---	0.46	---	-0.93
C2G1R11	-1.74	-1.06	---	-2.50	-0.49	-2.37	---	0.41	1.97	-0.32	-1.49	-4.24	0.56	-1.69
C2G1R13	0.88	0.16	---	2.18	---	---	---	0.75	-2.01	2.52	2.72	2.61	1.20	---
C2G1R15	-15.84	---	---	---	---	---	---	---	7.71	---	---	---	---	---
C3G1R17	6.86	---	---	4.12	---	---	4.74	6.67	4.12	5.94	3.11	8.73	7.08	7.71
C3G1R19	12.63	11.25	13.45	---	3.10	---	2.11	10.95	---	---	---	---	11.58	13.58
C3G121	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Note. Channels with "---" lost connection or data was not present following Artifact Subspace Reconstruction (ASR) in either the pre- or post- scan.
[a] Subject includes a cell number, group number and respondent identification number.

Table 2

Eyes Closed Pre- and Post- Difference of Theta Beta Ratio (TBR)

	EEG Channels													
Subject	AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
C1G2R1	---	---	---	---	---	---	---	---	---	2.12	2.91	2.81	1.89	1.93
C1G2R3	1.48	1.77	1.36	1.92	---	---	---	---	---	1.39	0.82	1.00	---	0.99
C1G2R5	---	---	1.01	1.29	3.66	-1.31	4.32	3.34	---	0.97	1.12	0.83	---	0.89
C1G3R7	---	---	---	---	---	---	---	---	---	-0.22	0.25	0.90	-0.02	---
C1G3R9	0.45	0.76	0.92	0.40	---	---	---	---	0.38	1.07	-0.04	0.72	-0.33	0.21
C2G1R11	---	-1.15	---	---	---	---	---	---	---	---	---	---	---	---
C2G1R13	0.27	---	---	2.29	---	---	---	-0.21	1.23	1.14	-1.30	0.84	-2.44	---
C2G1R15	-0.99	---	---	---	---	---	---	---	---	---	---	---	---	5.45
C3G1R17	2.34	---	2.79	---	---	---	---	3.63	3.59	3.95	2.09	3.90	3.90	---
C3G1R19	7.95	4.01	13.99	---	3.71	---	---	10.40	---	---	15.14	---	4.81	8.59
C3G121	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Note. Channels with "---" lost connection or data was not present following Artifact Subspace Reconstruction (ASR) in either the pre- or post-scan.
[a] Subject includes a cell number, group number and respondent identification number.

Figure 5. Eyes Open TBR (M +- std)

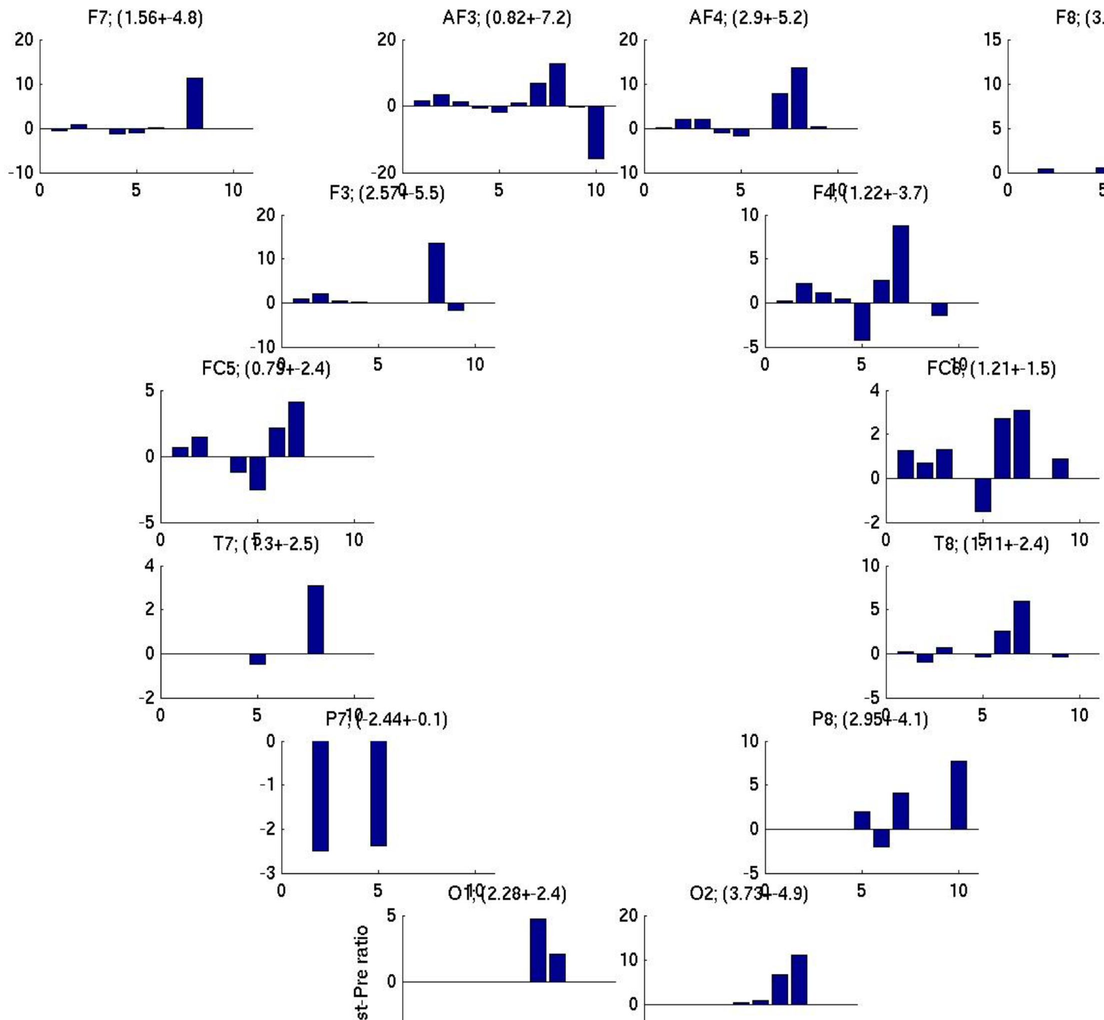

Figure 5. Difference of eyes open TBR pre- to post- green play at 14 channels with the beta range [13-18Hz]. Analyzed by Onton (2015) using EEG Lab following ASR. Increases in TBR are shown as bars above 0 and decreases in TBR are shown as bars below 0. Subjects with no bar present indicate that data was not recorded at that channel on either the pre- or post- scan.

Figure 6. Eyes Closed TBR (M +- std)

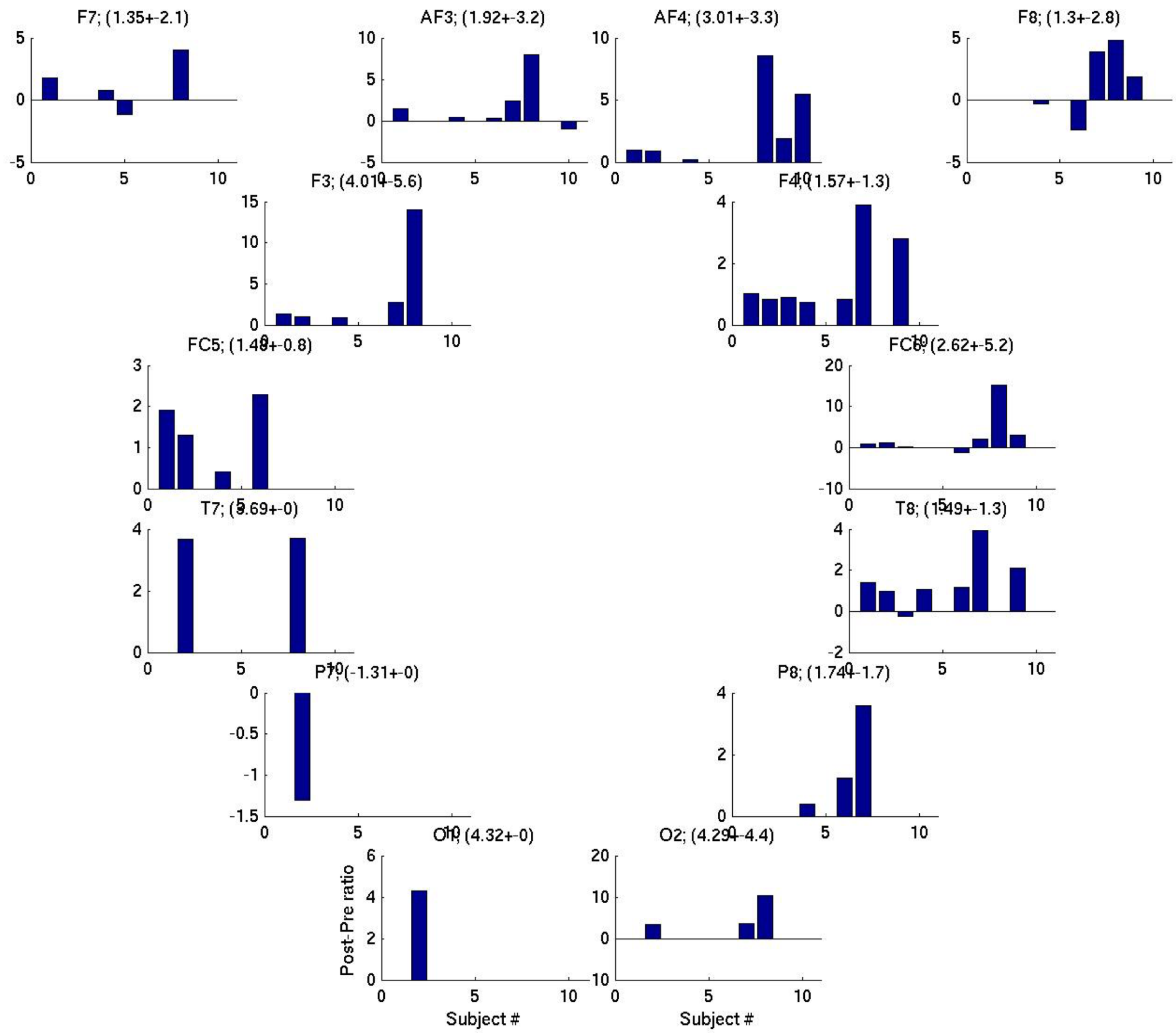

Figure 6. Difference of eyes closed TBR pre to post green play at 14 channels with the beta range [13-18Hz]. Analyzed by Onton (2015) using EEG Lab following ASR. Increases in TBR are shown as bars above 0 and decreases in TBR are shown as bars below 0. Subjects with no bar present indicate that data was not recorded at that channel on either the pre- or post- scan.

Continuous Performance Tests Results

Omission errors and sustained-attention. The results from the Continuous Performance Test (CPT) (Figure 7 and 8) suggest that ADHD children who participated in the green play have less omission errors (*M*= 18.75, *SD*= 15.06) when presented with an X-test than children with ADHD who took a placebo, (*M*= 33.44, *SD*= 15.57), $t(30) = 2.5626$, $p<0.0156$) (Michael et al., 1981). These analyses, which compare CPT of the experimental group with groups reported in the literature (Michael, Klorman, Salzman, Borgsted, & Dainer 1981), give support to Hypothesis 2 that green play helps increase sustained-attention ability in ADHD children. Additionally, children that participate in green play have less X-test omission errors (*M*= 18.75, *SD*=15.06) than children taking Methylphenidate (*M*= 25.97, *SD*=16.12), $t(30) = 1.2297$, $p<0.2284$); however this difference is not statistically significant. Additionally, despite the increased sustained-attention reported, ADHD children's X-test omission error scores (*M*= 18.75, *SD*=15.06) continued to be higher than non-ADHD children's scores (*M*= 16.29, *SD*=14.36), $t(30) = 0.4528$, $p<0.6540$); however this difference was not statistically significant. Despite the increase sustained-attention reported, ADHD children's X-test omission error scores (*M*= 18.75, *SD*=15.06) continued to be higher than normal children's scores (*M*= 16.29, *SD*=14.36), $t(30) = 0.4528$, $p<0.6540$); however, this difference was not statistically significant. Therefore, ADHD children who participated in green play may have greater sustained-attention ability than ADHD children who do not receive treatment, as well as comparable sustained-attention to ADHD children taking a methylphenidate and non-ADHD children as reported by Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Figure 7. X-Test Omissions Green Play vs. Placebo, Methylphenidate, and Non-ADHD Child

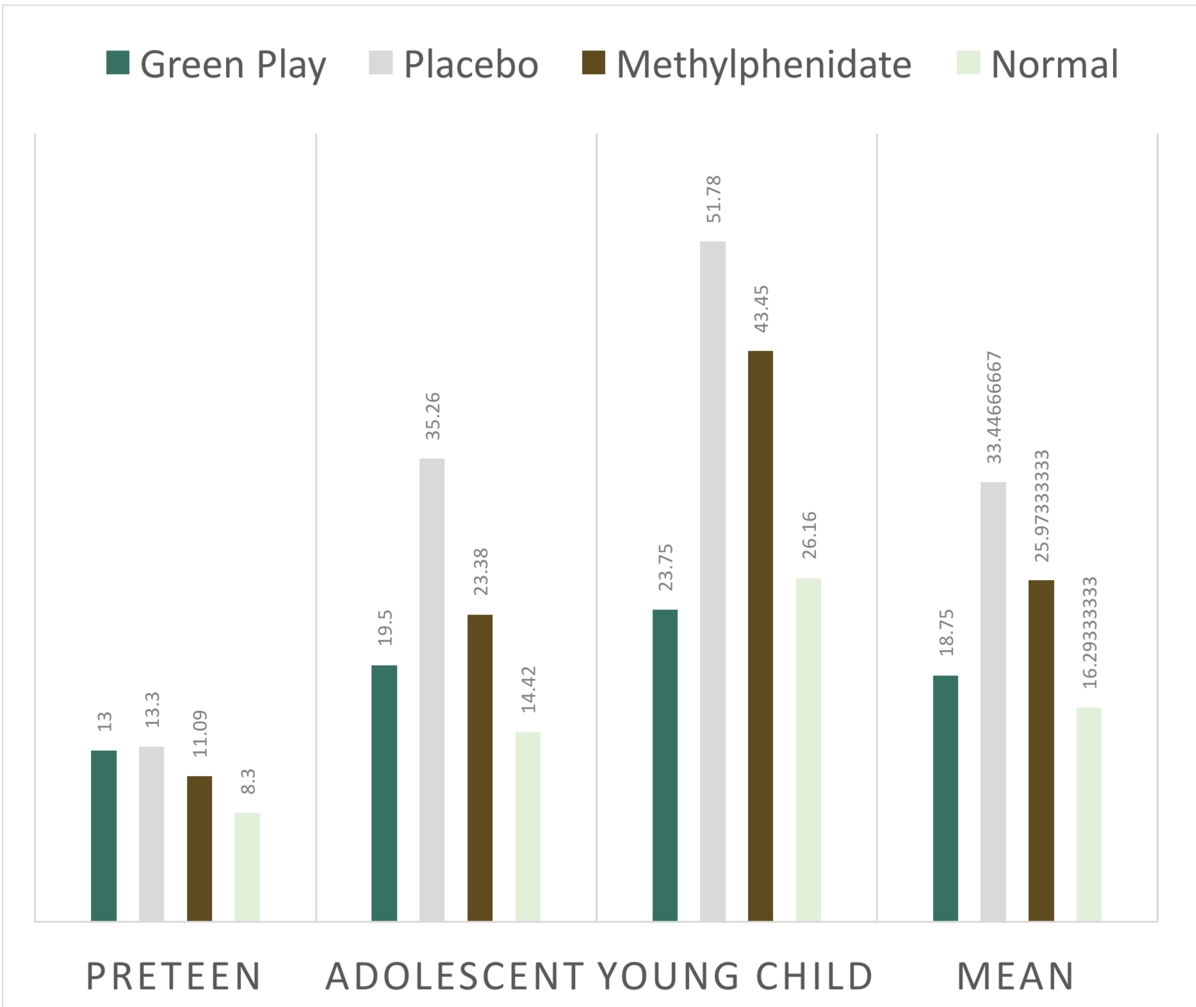

Figure 7. X-test omissions measure of sustained-attention of ADHD children following green play compared to norms of ADHD children on placebo, methylphenidate and normal children from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Figure 8. AX-Test Omissions Green Play vs. Placebo, Methylphenidate, and Non-ADHD

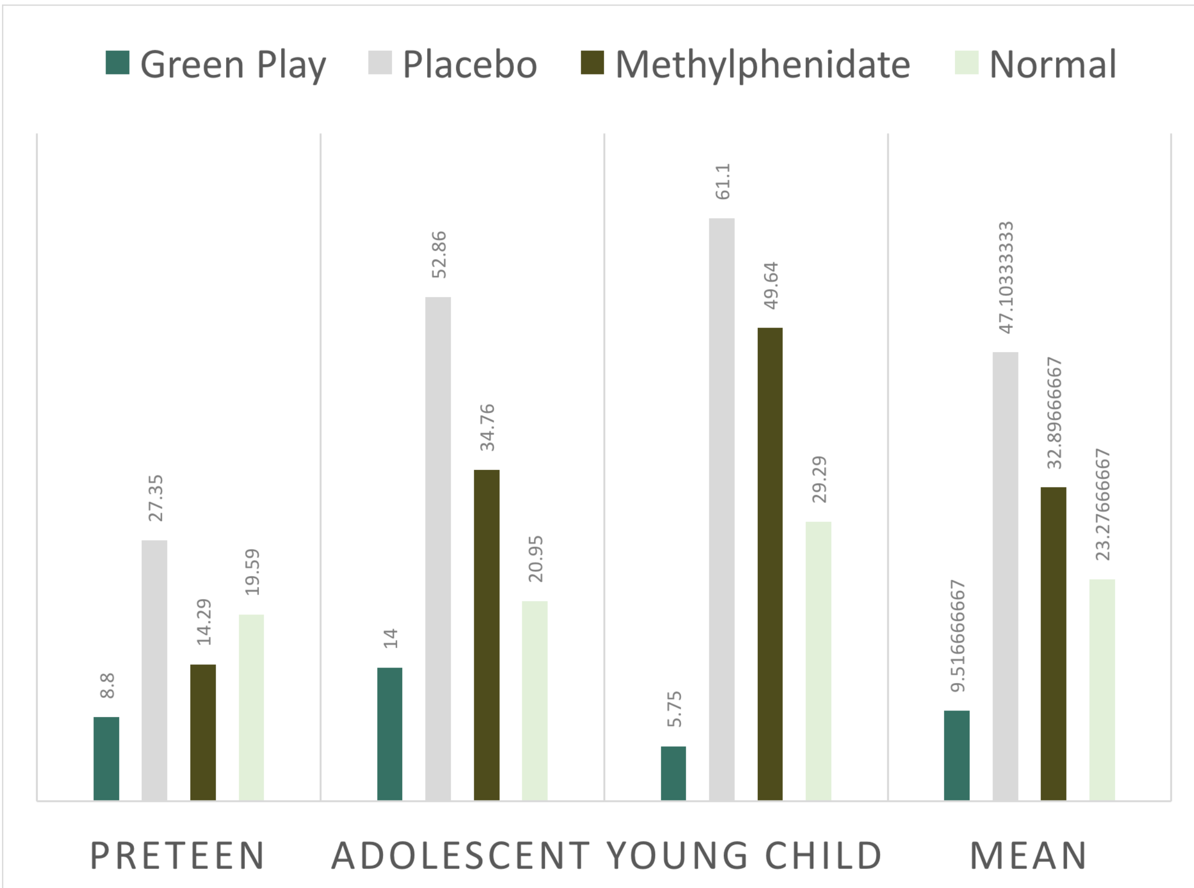

Figure 8. AX-test omissions measure of sustained-attention of ADHD children following green play compared to norms of ADHD children on placebo, methylphenidate and non-ADHD children from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Table 3

Comparison of X-Test Omissions and Commissions

X-Omissions

	Green Play				Placebo				Methylphenidate				Normal			
Ages	n	M	SD	S2	n	M	SD	S2	n	M	SD	S2	n	M	SD	S2
10.5-13	5	13	12.63	159.5	8	13.3	9.7	94.09	8	11.09	6.1	37.21	8	8.3	7.78	60.52
8.5-10.5	2	19.5	23.33	544.29	6	35.26	18.99	360.62	6	23.38	18.92	357.96	6	14.42	15.88	252.17
5.5-8.5	4	23.75	9.22	85.01	7	51.78	18.02	324.72	7	43.45	23.35	545.22	7	26.16	19.43	377.52
Total	11	18.75	15.06	262.93	21	33.44	15.57	259.81	21	25.97	16.12	313.46	21	16.29	14.36	230.07

X-Commissions

	Green Play				Placebo				Methylphenidate				Normal			
Ages	n	M	SD	S2	n	M	SD	S2	n	M	SD	S2	n	M	SD	S2
10.5-13	5	9.4	12.28	150.79	8	1.76	1.38	1.904	8	6.91	8.33	69.38	8	0.92	1.5	2.25
8.5-10.5	2	7.5	4.95	24.502	6	5.95	5.01	25.10	6	2.64	2.08	4.32	6	2	2.01	4.04
5.5-8.5	4	18	20.31	412.49	7	6.74	4.62	21.34	7	7.16	6.34	40.19	7	2.54	2.44	5.95
Total	11	11.63	12.51	156.58	21	4.81	3.67	13.46	21	5.57	5.58	31.17	21	1.82	1.98	3.93

Note. X-test omissions (sustained-attention) and X-test commissions (hyperactivity) for Green Play treatment group compared to norms from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Table 4

Comparison of AX-Test Omissions and Commissions

AX-Omissions

	Green Play				Placebo				Methylphenidate				Normal			
Ages	n	M	S	S2	n	M	S	S2	n	M	S	S2	n	M	S	S2
10.5-13	5	8.8	12.03	144.72	8	27.35	14.18	201.07	8	14.29	7.56	57.15	8	19.59	17.41	303.10
8.5-10.5	2	14	16.97	287.98	6	52.86	19.02	361.76	6	34.76	11.63	135.25	6	20.95	24.02	576.96
5.5-8.5	4	5.75	2.06	4.24	7	61.1	20.64	426.00	7	49.64	26.84	720.38	7	29.29	18.88	356.45
	1															
Total	1	9.51	10.35	107.19	21	47.10	17.94	322.08	21	32.89	15.34	235.41	21	23.27	20.10	404.14

AX-Commissions

	Green Play				Placebo				Methylphenidate				Normal			
Ages	n	M	S	S2	n	M	S	S2	n	M	S	S2	n	M	S	S2
10.5-13	5	9.4	12.28	150.79	8	1.76	1.38	1.904	8	6.91	8.33	69.38	8	0.92	1.5	2.25
8.5-10.5	2	7.5	4.95	24.502	6	5.95	5.01	25.10	6	2.64	2.08	4.32	6	2	2.01	4.04
5.5-8.5	4	18	20.31	412.49	7	6.74	4.62	21.34	7	7.16	6.34	40.19	7	2.54	2.44	5.95
Total	1	11.63	12.51	156.58		4.81	3.67	13.46		5.57	5.58	31.17		1.82	1.98	3.93
	1				21				21				21			

Note. AX-test omissions (sustained-attention) and AX-test commissions (hyperactivity) for Green Play treatment group compared to norms from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

While the X-test omission errors show a significant difference between ADHD children who participate in green play versus ADHD children with a placebo, the most significant finding was the green play group's AX-test omission scores. AX-test omission scores (M= 9.51, SD=10.35) were significantly less than Michael et al. (1981) placebo group (M= 47.10, SD=17.94), $t(30) = 6.3812$, $p<0.0001$), methylphenidate group (M= 32.89, SD=15.34), $t(30) = 4.5255$, $p<0.0001$), and normal group (M= 23.27, SD=20.10), $t(30) = 2.1163$, $p<0.0427$).

Commission errors and hypervigilance. ADHD children who participated in green play have greater commission errors (M= 11.63, SD=12.51) when presented with an X-test than children with ADHD who were given a placebo (M= 4.81, SD=3.67), $t(30) = 2.3433$, $p<0.0259$). However, green play children compared to children on a methylphenidates was not quite statistically significant (M= 5.57, SD=5.58), $t(30) = 1.9066$, $p<0.0662$). Similarly, ADHD children who participate in green play (M= 11.16, SD=12.56), performed worse on AX-tests than ADHD children who were given a placebo (M= 3.54, SD=2.74), $t(30) = 2.6973$, $p<0.0114$), or on methylphenidates (M= 2.94, SD=2.61), $t(30) = 2.9229$, $p<0.0065$). These results support the hypothesis 2 that while green play aids children in increasing sustained-attention it may not significantly affect the child's hypervigilance regulation as reported in the literature (Michael, et al., 1981).

Figure 9. X-Test Commissions Green Play vs. Placebo, Methylphenidate, and Non-ADHD

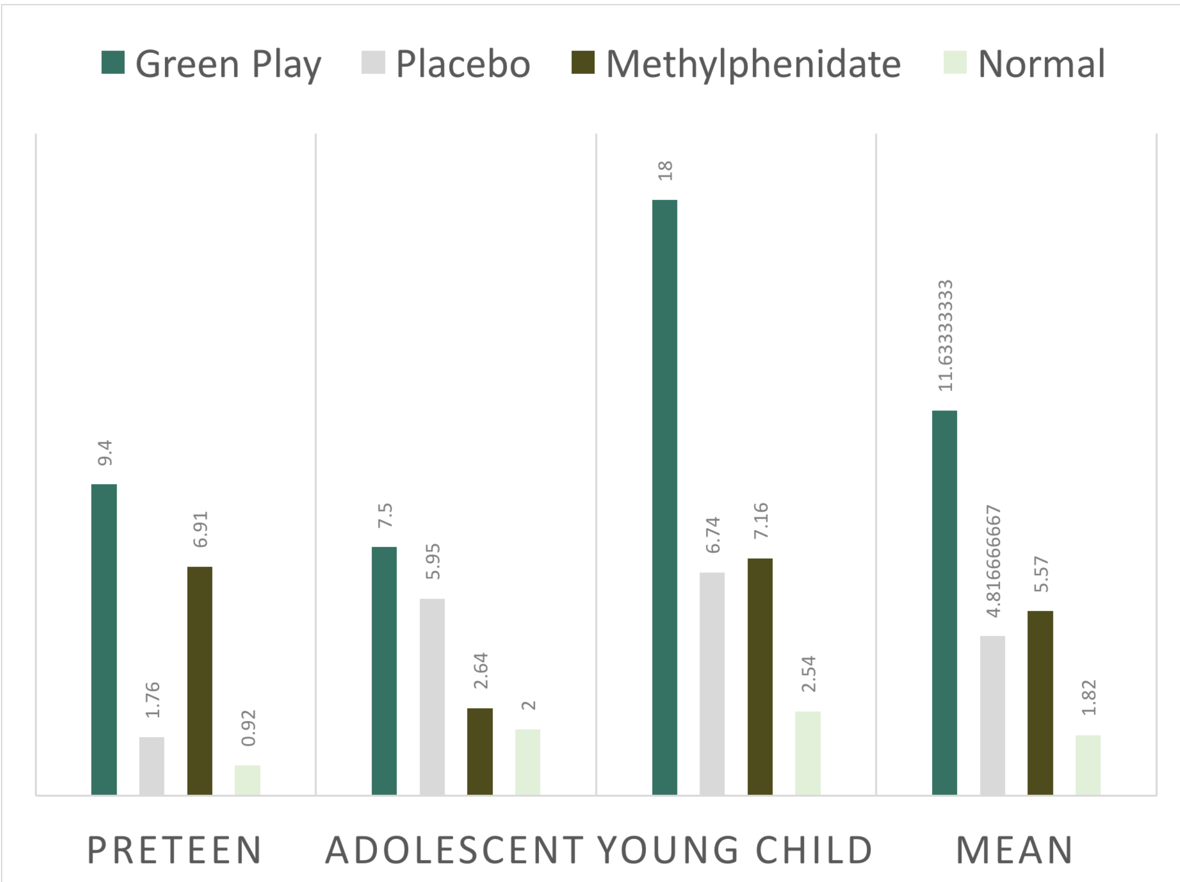

Figure 9. X-Test commissions measure hypervigilance after green play compared to norms of ADHD children on placebo, methylphenidate and normal children from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Figure 10. AX-Test Commissions Green Play vs. Placebo, Methylphenidate, and Non-ADHD

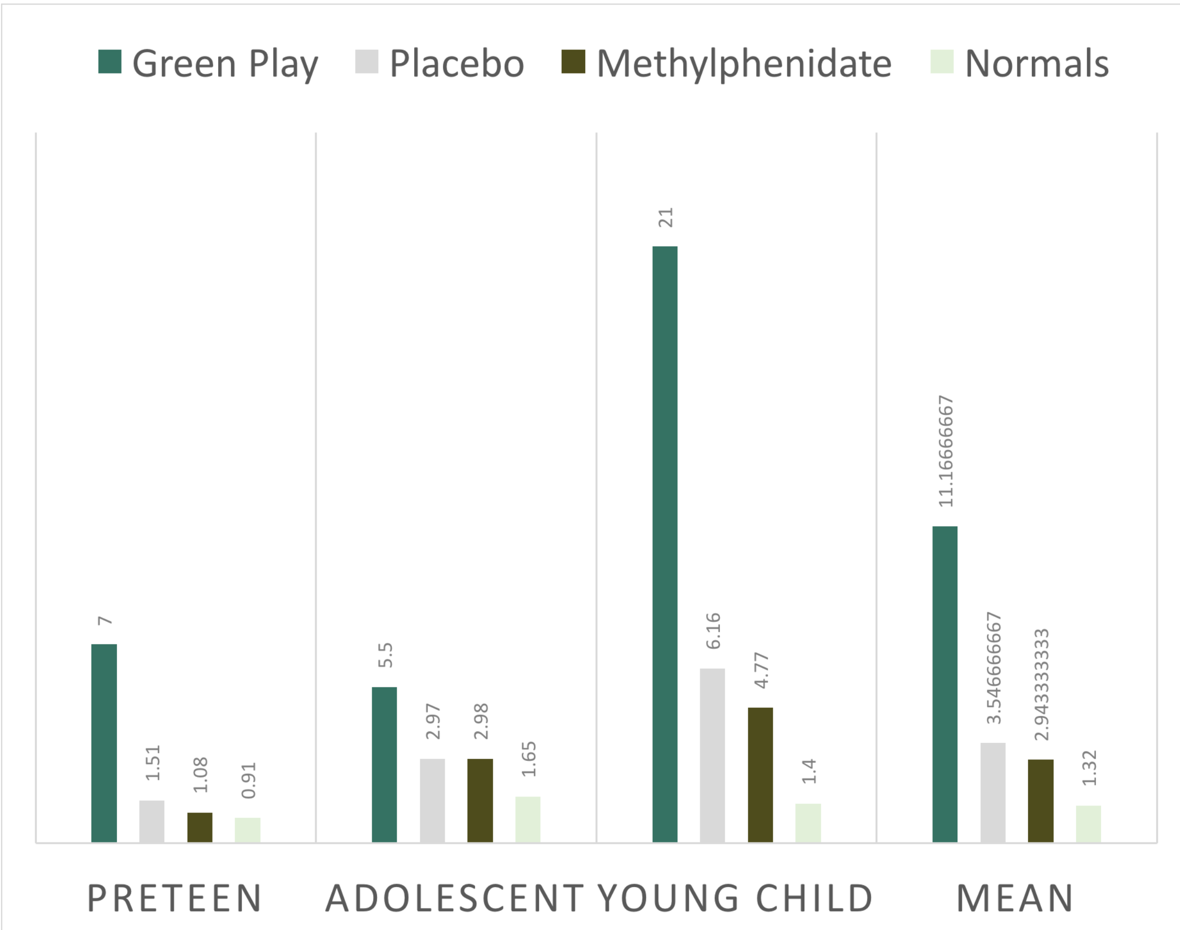

Figure 10. AX-Test commissions measure of hypervigilance following green play compared to norms of ADHD children on placebo, methylphenidate and non-ADHD children -from Michael, Klorman, Salzman, Borgstedt, & Dainer (1981).

Perceived Restorative Scale Results

Eleven children total completed the Perceived Restorative Scale (PRS) following the walk, post-EEG scan, and CPT test. Results supported the hypothesis that children would perceive the green play environment as restorative (Figure 11-13). Overall, children perceived the environment 75% restorative, which included features of fascination and having extent.

Figure 11. Perceived Restorative Scale

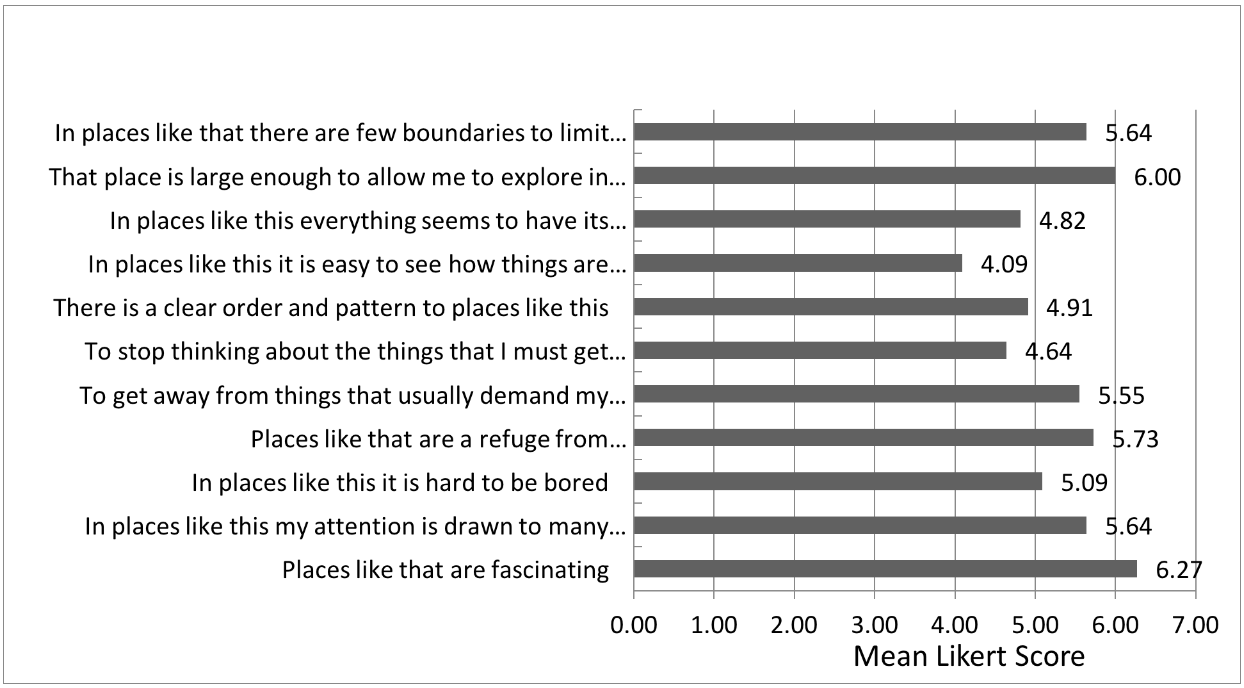

Figure 11. Mean perceived restorative effects of the green play environment based off ADHD children's feedback on a 7-point Likert scale (n=11) (Pasini et al., 2014).

Figure 12. Minimum, Maximum, Median, Mean, and Standard Deviation

	Minimum	Maximum	Median	Mean	Standard Deviation
Places like that are fascinating	5.00	7.00	7.00	6.27	0.86
In places like this my attention is drawn to many interesting things	2.00	7.00	6.00	5.64	1.49
In places like this it is hard to be bored	1.00	7.00	6.00	5.09	2.02
Places like that are a refuge from problems/annoyances	2.00	7.00	6.00	5.73	1.29
To get away from things that usually demand my attention I like to go to places like this	1.00	7.00	6.00	5.55	1.78
To stop thinking about the things that I must get done I like to go to places like this	2.00	7.00	5.00	4.64	1.49
There is a clear order and pattern to places like this	2.00	6.00	6.00	4.91	1.50
In places like this it is easy to see how things are organized	2.00	6.00	5.00	4.09	1.68
In places like this everything seems to have its proper place	2.00	7.00	5.00	4.82	1.85
That place is large enough to allow me to explore in many directions	5.00	7.00	6.00	6.00	0.85
In places like that there are few boundaries to limit me from moving about	2.00	7.00	6.00	5.64	1.49

Figure 12. Minimum, maximum, median, mean, and standard deviation from 7-point Likert scale on the perceived restorative effects of the green play environment rated by ADHD children.

Figure 13. Individual Item Results from PRS-11

	Strongly Disagree (1)	Disagree (2)	Disagree Somewhat (3)	Undecided (4)	Agree Somewhat (5)	Agree (6)	Strongly Agree (7)	Total	Weighted Average
Places like that are fascinating	0.00% 0	0.00% 0	0.00% 0	0.00% 0	27.27% 3	18.18% 2	54.55% 6	11	6.27
In places like this my attention is drawn to many interesting things	0.00% 0	9.09% 1	0.00% 0	9.09% 1	18.18% 2	27.27% 3	36.36% 4	11	5.64
In places like this it is hard to be bored	9.09% 1	9.09% 1	0.00% 0	18.18% 2	9.09% 1	18.18% 2	36.36% 4	11	5.09
Places like that are a refuge from problems/annoyances	0.00% 0	9.09% 1	0.00% 0	0.00% 0	9.09% 1	63.64% 7	18.18% 2	11	5.73
To get away from things that usually demand my attention I like to go to places like this	9.09% 1	0.00% 0	0.00% 0	18.18% 2	0.00% 0	36.36% 4	36.36% 4	11	5.55
To stop thinking about the things that I must get done I like to go to places like this	0.00% 0	18.18% 2	0.00% 0	18.18% 2	36.36% 4	18.18% 2	9.09% 1	11	4.64
There is a clear order and pattern to places like this	0.00% 0	18.18% 2	0.00% 0	9.09% 1	18.18% 2	54.55% 6	0.00% 0	11	4.91
In places like this it is easy to see how things are organized	0.00% 0	36.36% 4	0.00% 0	9.09% 1	27.27% 3	27.27% 3	0.00% 0	11	4.09
In places like this everything seems to have its proper place	0.00% 0	27.27% 3	0.00% 0	0.00% 0	27.27% 3	27.27% 3	18.18% 2	11	4.82
That place is large enough to allow me to explore in many directions	0.00% 0	0.00% 0	0.00% 0	0.00% 0	36.36% 4	27.27% 3	36.36% 4	11	6.00
In places like that there are few boundaries to limit me from moving about	0.00% 0	9.09% 1	0.00% 0	9.09% 1	18.18% 2	27.27% 3	36.36% 4	11	5.64

Figure 13. Individual item results from 7-point Likert scale on the perceived restorative effect of the green play environment rated by ADHD children. (Pasini et al., 2014).

Solar Intensity (SI)

Though Solar Intensity (SI) was measured throughout the walk, a formatting malfunction prevented aggregation of data that had been recorded using the Pyle Meter was unable to be aggregated due to formatting malfunction. Furthermore, since the perceived restorative scores from the children's surveys showed that the children deemed the environment as restorative, the SI was considered less important to analyze at this time.

CHAPTER 5.

DISCUSSION AND RECOMMENDATIONS

As stated in the results, it was hypothesized that ADHD children would respond to a Green Play treatment in three ways: 1) their EEG scans would show a decrease in theta/beta ratio (TBR), indicating that sustained-attention ability and hypervigilance regulation increased (Arns et al., 2001); 2) their Continuous Performance Tests (CPT) (Rosvold et al., 1956) would show less omission and commission errors than ADHD children taking a placebo (Michael, Klorman, Salzman, Borgstedt, & Dainer, 1981); and 3) that their Perceived Restorative Scales would substantiate children's natural affinity and perceived restorative effects of the green play environment (Bagot, 2004; Bagot, Kuo, & Allen, 2007). Evidence in support hypothesis 2 (H2) and hypothesis 3 (H3) was found, and numerous limitations concerning the method of recording theta/beta ratio (TBR) for hypothesis 1 (H1) were documented.

The neurological measure of electroencephalogram (EEG) scans for theta/beta ratio (TBR) suggests that following green play, ADHD children's TBR increases rather than decreases. This does not support hypothesis 1 (H1), which states that green play will increase sustained-attention and hypervigilance regulation in ADHD children. However, there are several confounding variables and technical issues with this study that warrant a replication of this experiment with new equipment, refined data collection techniques, and a larger sample size within a familiar environment, rather than a novel one.

Hypothesis 2 (H2), which stated that the behavioral measure of a CPT test would show that children who participate in green play would have better sustained-attention and hypervigilance regulation following the treatment, was partly supported. When the current experimental group was compared with other groups of children reported in the literature by Michael, Klorman, Salzman, Borgstedt, & Dainer (1981), there was significant behavioral evidence that children's sustained-attention ability increased following a thirty-minute walk in a green playscape. There was also significant behavioral evidence that a 30-minute walk does not curb hypermotor activity or hypervigilance.

Hypothesis 3 (H3) stated that children would perceive restorative effects of the green play environment as shown on a PRS-11 (Bagot, 2004; Bagot, Kuo, & Allen, 2007). The majority of the ADHD children perceived the green play environment to be restorative and deemed it a place they would go to recharge their attention. One might wonder, however, if this excitement following the novel environment and stimulus they experienced fueled their motor activity once they returned to the testing room, thus increasing their hyperactivity/impulsivity scores on the CPT behavioral test.

Limitations of the Study

Small sample size. Due to the nature of school schedules, availability of vegetation, and the IRB's suggestion for Saturday testing rather than during a school day, scheduling subjects for the study proved difficult. Twenty-two public or charter schools were contacted in Buncombe County or Asheville City district. Seven of the school's counselors or IEP coordinators responded and passed out flyers about the study to parents of ADHD children. Two homeschool groups and two parent social media groups posted notices, and three counselors/psychiatrists passed out flyers to patients. One pharmacist also notified potential families about the study via flyers within medication bags. Despite eight weeks of advertising via these vehicles and on social media, only eleven children came to participate. In the future, working with a single local psychiatrist or school counselor and completing the study at their office or school in a known environment might yield more participants. This familiarity of space and staff, would add in receiving a true baseline EEG scan for student's pre-test, rather than a novel one. As well, recruitment should not commence in the months of May and June due to the numerous school activities and family commitments in those months (e.g. graduation, end of grade testing, and family vacations).

Cz versus F4 and F8. Following the analysis of F4 and F8 and the other twelve channels, further research was conducted on other TBR studies. The most significant differences of TBR can be found when using one source electrode at the Cz (Arns et al., 2011; Hamlin, personal communication, August 26, 2015). Due to its midline connection to both the anterior cingulate gyrus (the hub of affect/emotional regulation) and the posterior cingulate gyrus aligned with the working memory, a Cz channel that is overactive is the best evidence of disorders such as ADHD (Arns et al., 2011; Hamlin, personal communication, August 26, 2015; Warner, 2013). Since the *Emotiv* headsets have 14 source electrodes, none of which lie at the Cz, it is suggested that the study be repeated with one source electrode at the Cz. This is evident in the lack of relationship present in the homologous pairs of F7 and F8, AF3 and AF4, F3 and F4, FC5 and FC6, T7 and T8, P7 and P8, and O1 and O2. In general, properly executed EEG scans should have a mirroring effect in both the right and left hemispheres of the brain. If this is not present, it can be assumed that the scan lost connectivity, the helmet shifted to one side, or another electrical impulse was present (Hamlin, personal communication, August 26, 2015). Likewise, the theta and beta waves both posterior and anterior should have similar increases or decreases due to their relationship with controlling sustained-attention (Hamlin, personal communication, August 26, 2015).

Lack of connectivity. A one-source electrode scan will also aid in reducing connectivity issues that were present with the *Emotiv* headsets. Constructed for adults, the headsets did not fully fit children and frequently slid out of place or stopped contact midway through the scan. Due to this movement, scans were recorded from 47-101 seconds instead of the standard 90 seconds presented by Monastra, et al. (1999). Another reason for lack of connectivity was corrosion of the copper source electrodes, probably attributed to humidity present in the Southeast region. After the first testing cell, electrodes were cleaned with a bristle brush in order to increase connectivity for Cells 2 and 3.

Beta ranges. Because high beta ranges (18Hz and up) are evidence of irritability and agitation, it is suggested that when the study is replicated there only be an analysis of beta at 13-18Hz which includes both the low range and midrange beta levels but alleviates the high beta range. This is especially important since a sub-type of ADHD has been found to have high-beta, and a pre-screen for that tendency was not completed.

Eyes open, closed and visual. The discrepancies between eyes open and eyes closed scans were apparent, and yet superfluous. Eyes closed scans can naturally allow theta to increase in children simply because they begin to visualize images or situations, especially following stimulant-rich experiences (Hamlin, personal communication, August 26, 2015). These increased theta frequencies resulting from visualization could easily skew the TBR. It is suggested in the future to replace this scan with a working task scan. The visual “looking around” scan was originally taken to have a comparison between a resting state and working state; however, frequent occurrence of peripheral impulses complicated analysis of the scans (Onton, personal communication, August 24, 2015). Other researchers have used working scans with children in tasks involving reading, writing, drawing, or even completing a Continuous Performance Test (CPT) as a valid measure of a working state (Arns et al., 2011; Onton, personal communication, August 12, 2015; Michael, Klorman, Salzman, Borgstedt, & Dainer, 1981).

Working tasks with CPT. Adding a working scan while in the midst of the CPT will clarify how TBR is affected following the walk in the context of working states, rather than in resting states. . The mere fact that theta frequencies are generally elevated during resting states is a major confounding variable. Additionally, there are several CPTs that have been developed since Rosvold et al. CPT (1956) that feature larger national norms and more descriptive analysis, including reaction times. These sustained-attention and hyperactivity tests, such as the Conner's Continuous Performance Test (CCPT), were cost-prohibitive at this time, but are suggested for further studies. The consistency of tests should alleviate the difference of distractor numbers (25 or 6) shown to the ADHD children. Currently, the variance between the twenty-five letters presented as distractors in Rosvold's CPT (1956) and the six letters presented as distractors in Michael et al. (1981) may have affected the novelty of the tasks, thereby decreasing the omission scores for the green play group compared to the norms.

Re-craft perceived restorative scale. Furthermore, the modified Perceived Restorative Scale (PRS-II) (Pasini et al., 2014), was found to be laborious and confusing for ADHD children ages 7-13 years old. Though it was presented orally, the 7-point Likert scale and the language in which the sentences were crafted confused children. For future work, it is suggested to revise the scale to a 3 or 5-point Likert scale and edit sentences that correspond to the four components of restoration.

Environmental variables. The most significant confounding variables are 1) the novelty of the environment in which the children participated in the pre-test and 2) the novelty of the EEG scan. For all eleven children, this was their first EEG scan of any kind and for the majority it was also their first visit to the Montreat campus. The sheer fact that it was a new stimulus and new environment could have skewed their TBR. A deescalated pre-TBR could have masked their true resting state EEG dynamics (Hamlin, personal communication, August 26, 2015). When returning to the testing room for the post-test, or by repeating the EEG scan a second time, it could be that children's TBR increased due to decrease in novelty of stimulus and/or environment. In order to control this variable for future studies, it would be important conduct research in a location that is familiar to students such as their school or psychiatrist's office. Also, it is important to perform several ancillary scans in advance of the testing date. This would allow children to become accustomed to the scanner, the proctor and the process, effectively removing the novelty factor for a true resting state to be measured.

Conclusion

While this study did not support hypothesis (H1) that green play has a neurological restorative effect on TBR, it does suggest that further work is needed in order to understand the mechanisms of restoration following green play. When the current experimental group was compared with other groups of children reported in the literature by Michael et al. (1981), there was significant behavioral evidence that children's sustained-attention ability increased following a thirty-minute walk in a green play environment. There was also significant behavioral evidence that a thirty-minute walk does not curb hypermotor activity, or hypervigilance. In the future, expanding the ADHD testing to include varied working tasks will yield a fuller understanding of nature's impact on ADHD behavior. Additionally, mirroring EEG scans as a neurological measure can provide critical insight into this behavioral process. TBR has been documented to be a prognostic measure of ADHD symptoms (Arns et al., 2012); therefore, the behavioral scores on the CPT should be noted neurologically as well. These scans should be measured at Cz to remove peripheral impulses.

Suggestions for Further Study

It is vital to remember that nature is composed of various biotic and abiotic factors that deserve further exploration. In order to understand the effect of green play on ADHD children, other factors besides perceived restoration should be measured. For instance, the potential impact of Solar Intensity (SI) on theta/beta ratios (TBR) is an important area of future study. Additionally, other variables such as air quality, cardiovascular exertion, vegetation, and aesthetics should be tested. These individual factors are important to explore, and will help us determine if nature really is the best medicine.

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APPENDIX A

GREEN PLAY & ADHD

Dear parent or guardian,

I wanted to first thank you for considering your child's participation in my research study, "Green Play: Restorative Neurobehavioral Effects on ADHD children" for Montreat College's Master's in Environmental Education program. As a mother of an ADHD child myself, I want also share with you my passion for this topic as you consider your child's eligibility for the study.

After adopting our daughter at the age of 7, we realized quickly, with the help of our doctor, that our best way of helping her succeed and manage her ADHD symptoms in an educational setting was to consider using stimulant medication. While, we found stimulants to work very effectively, we also wondered if there were other options that would or could be as effective. Following much research, we concluded that a daily medication would be best. However, a funny thing happened. We ended up the coast of North Carolina on a sailing trip, and realized that we were without her script. Without a refill, we were worried that the trip would be a bust. Instead, however, she was a delightful child and was focused on catching jelly fish, building elaborate Egyptian temples out of sand, and learning the ins and outs of boat life with my husband. We read nightly and she engaged in games and activities with no problem. We left that trip wondering.

As I began my master's research, Richard's Louv book, "Last Child in the Woods" was published, and he mentioned that several researchers were looking into "green play" or outdoor play in a natural setting and how it affected ADHD symptoms. To my surprise one research team Faber-Taylor & Kuo had concluded that a walk in the park aided ADHD children in increasing concentration (2010).

For my research, I will be taking Faber-Taylor & Kuo's model of walking children through a green play area, and then recording their brain waves both pre and post walk. The tracking of their brain waves will be taken using electroencephalogram (EEG) that was approved by the FDA in 2013. This system looks similar to a bike helmet and will remain on the child's head for up to 5 minutes before and after the walk. The EEG will aid me in knowing how the child's brain waves changed before and after the outdoor walk, thus showing if they are less hyperactive following the intervention. As well, following the walk children will participate in a concentration test called a visual Conjunctive CPT (CCPT), and an oral survey about how they enjoyed the walk.

All data from the study will be kept confidential using a numbering system. However, if you would like to see your child's results from the study, we will gladly send them to you following the study. Please read the "Consent Form" attached and visit www.greenplay-adhd.com for more information about the study. As well, feel free to reach out to me with any further questions or concerns.

Sincerely,

Mel Wilson
Montreat College MSEE candidate
828-712-8574
mwilson14@montreat.edu

APPENDIX B

MONTREAT COLLEGE Research Consent Form **IRB Use Only**
MSEE Committee Chair: Dr. Brad Daniel Approval Date: ________________

Please check one of the following:

_____ You are an adult participant in this study.

_____ You are the parent or guardian granting permission for a child in this study.
Print child's name here: ____

The following information applies to the adult participant or to the child or ward. If the participant is a child or ward, the use of "you" refers to "your child" or "your ward."

DESCRIPTION: The reason for this study is to find out more about ADHD children feel and act following walking outside in a natural (or green) setting. This study is not experimental, and has been done before. There is current research that suggests that following a walk outside children have less ADHD symptoms (meaning that they are less fidgety, are able to concentrate more easily, are able to follow through with instructions more easily, are less impulsive, and are less distracted). However, the difference in those studies and this one, is that during this study I will also be recording your brain waves before and after the study using an EEG. The EEG will read your brain waves, using something similar to a bike helmet. It will stay on your head for up to five minutes will you sit and watch a blank wall. After the reading, you will go on a walk with a leader and 3 other children. During the walk you will be on the Black Mountain Greenway which goes along a creek and a forest. You will walk for 30 minutes. When you return you will have another EEG reading, and will participate in a concentration test, that helps to see how well you focus. An assistant will also ask you questions about the walk to see how you enjoyed it, and what you thought about the green setting.

TIME INVOLVEMENT: Your participation will take approximately 1.5-*2.5 hours.*

RISKS AND BENEFITS: The FDA (Food and Drug Administration) has tested this type of EEG test for ADHD children and says it is safe to use. During the EEG, the bike helmet like apparatus, can sometimes feel funny or tight on your head. However, there is no pain involved. If you do feel discomfort please tell the researcher right away. As well, on the walk the pace will be moderate and it will not be a run. However, whenever you are walking on a trail or a path there is the risk of twisting an ankle. Please remember to listen carefully to your leader, and let them know of any discomfort as you walk.

The benefits which may reasonably be expected to result from this study are that you will aid in helping ADHD children in the future by finding ways for them to concentrate and better manage their ADHD symptoms. As well, following the study you will receive the results of your tests.

This will help you and your parents to determine if walking in a green play area aids you in controlling your ADHD symptoms. If your results are positive, it would be a good idea to make outside play a regular part of your daily life. **We cannot and do not guarantee or promise that you will receive any benefits from this study.**

PAYMENTS: You will not receive payment for your participation.

PARTICIPANT'S RIGHTS: If you have read this form and have decided to participate in this project, please understand your **participation is voluntary** and you have the **right to withdraw your consent or discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled**. **The alternative is not to participate.** You have the right to refuse to answer particular questions. The results of this research study may be presented at scientific or professional meetings or published in scientific journals. Identities will be kept confidential.

CONTACT INFORMATION:
Questions: If you have any questions, concerns or complaints about this research, its procedures, risks and benefits, contact the Committee Chair Dr. Brad Daniel 828-669-8011.

Independent Contact: If you are not satisfied with how this study is being conducted, or if you have any concerns, complaints, or general questions about the research or your rights as a participant, please contact the Montreat College Institutional Review Board (IRB) to speak to someone independent of the research team at (828)669-8011. You can also write to the Montreat College IRB, 310 Gaither Circle, Montreat, NC 28757.

Appointment Contact: If you need to change your appointment, please contact Mel Wilson at 828-712-8574 or mwilson14@montreat.edu.

The extra copy of this signed and dated consent form is for you to keep.

SIGNATURE ________________________________ **DATE** _____________