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An Investigation of Brain Games as a Potential Non-Pharmaceutical Alternative for the Treatment of ADHD

Stacy C. Wegrzyn
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AN INVESTIGATION OF BRAIN GAMES AS A POTENTIAL
NON-PHARMACEUTICAL ALTERNATIVE FOR
THE TREATMENT OF ADHD

by

Stacy C. Wegrzyn

A Dissertation

Presented in Partial Fulfillment of Requirements for the
Degree of
Doctor of Education

In
Teacher Leadership for Learning

In the
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Brain Games and ADHD

Dissertation Signature Page

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Date: 10/27/11
Dedication

I dedicate the final product of this five-year journey to the love of my life,
Brian Wegrzyn, our precious daughter Alyse, my loving parents, Linda and Dennis
Compton, and my wonderful father-in-law, Winslow Wegrzyn. For you I persevered
when I wanted to give up, and for you I am grateful.
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To my participants and their families, thank you for sharing such a personal part of your lives with me. This research would not have been possible without your involvement. Your effort and commitment will not be forgotten.
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To my dear friend, Tricia Frazier, from submitting our applications to the doctoral program, to the final celebration of our accomplishment, I am so glad that we were side-by-side. Plus who would have that thought we would both become mommies for the first time in the middle of it all. We rock!

To my friends and family, thanks for your help and encouragement along the way. To my father-in-law, Winslow Wegrzyn, your generosity allowed my research vision to become a reality. Thank you for your support, and the confidence you had in me, throughout this process. To my parents, Linda and Dennis Compton, for many reasons, I could not have done this without you. Thank you for your generosity and unselfishness in making my education a priority for our family. My greatest reward is that I have made you proud. I love you all dearly!

To the love of my life, Brian Wegrzyn, thank you for riding this roller coaster with me. Your help with everything along the way has meant so much. Thank you for holding our little family together while my head was in the clouds of academia. Finally, to our precious daughter, Alyse Makenna Wegrzyn, thank you for coming into my life at the perfect time. There is nothing that motivated me more than knowing that when I got to the end of this journey, I would have all the more time to spend with you and your daddy. I love you both more than words can say.

Last, but not least, I would like to thank God... for answering so many prayers along the way.
Abstract

AN INVESTIGATION OF BRAIN GAMES AS A POTENTIAL NON-PHARMACEUTICAL ALTERNATIVE FOR THE TREATMENT OF ADHD

by Stacy C. Wegrzyn

This study sought to determine if the daily use of brain games such as Nintendo DS Brain Age could increase the engagement of students with ADHD. The findings bridge the gap between prior research on the frontal lobe’s connection to ADHD and the studies that have indicated brain games can stimulate this area of the brain. Based on the compilation of data, there is hope for ADHD patients searching for an alternative to medication. Data from seven of the nine instruments utilized in this study support the overarching hypothesis that the daily use of brain games can help decrease the theta/beta ratio of those with ADHD, while improving their ability to focus, and strengthening their executive functioning ability.

Keywords: ADHD, brain games, engagement, focus, executive functioning, theta/beta ratio, EEG, treatment, alternative to medication
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Chapter 1: Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most frequently diagnosed childhood psychiatric disorders (Halperin & Schulz, 2006). Children with this disorder typically exhibit behaviors that are spurred by inattentiveness, hyperactivity, or a combination of both. Although ADHD is not considered a learning disability, its effects can make learning a greater challenge for students (Samuels, 2005). As a result, approximately two and a half million students take daily stimulant medication to treat the symptoms (Phelan, 2006). The theory behind these medications is that they adhere to important neurotransmitters, dopamine and norepinephrine, which are typically in short supply in students with ADHD. The medications then activate these neurotransmitters in order to stimulate the prefrontal cortex (Szegedy-Maszak, 2002).

There is ample research supporting the theory that ADHD is caused by dysfunction in the brain’s prefrontal cortex (Barkley, 1997; Brennan & Arnsten, 2008; Dickstein, Bannon, Xavier Castellanos, & Milham, 2006; Dige & Wik, 2005). Studies have shown that, as a result, children with ADHD do not perform as well as control students in tests of their executive functions (Adler, Spencer, Stein, & Newcorn, 2008; Halperin & Schulz, 2006; Mares, McLuckie, Schwartz, & Saini, 2007). Accordingly, the executive dysfunction theory/framework of ADHD is based on the premise that the symptoms of ADHD are caused by a reduced level of executive
control, which is the result of structural and chemical abnormalities in the prefrontal cortex of the brain (Johnson, Wiersema, & Kuntsi, 2009). Executive functions are instrumental in focusing, switching focus, and dividing attention (Johnson et al., 2009). Students with a deficit in these areas find ignoring distractions difficult, and many other functions that support metacognition a challenge (Brown, 2009). The executive dysfunction framework is therefore most suitable for studying symptoms of ADHD that are related to inattention and lack of focus (Johnson et al., 2009).

One relatively new genre of research that is not highly recognized in the literature about ADHD is that of brain games. Based on the research of Ryuta Kawashima (2005), which claims that activities such as rapid mathematical calculations and reading aloud can increase activity in the prefrontal cortex, companies such as Nintendo have created a new line of brain games. For example, the Nintendo DS game Brain Age (NDSBA) allows users to participate in 10 different games that are modeled after those in Kawashima’s studies (Crecente, 2006). Although Kawashima has conducted studies that showed the benefits of brain games in geriatric patients with dementia, there is no published research in the area of using these games to help students with ADHD. Based on the literature, it seemed feasible that playing brain games such as NDSBA could stimulate the prefrontal cortex of students with ADHD, simulating the effects of stimulant medication, thus helping these students improve their ability to engage in classroom activity and perform tasks of executive function. There was promise in this intervention, as there are no known negative side effects of brain game use, and it is relatively
affordable and convenient option compared to many of the other alternative treatments.

The remainder of this chapter will be presented in 10 sections: The Nature of ADHD, Purpose of the Study, Significance of the Study, Definition of Terms, Theoretical Frameworks, Research Questions, Limitations, Delimitations, Implications, and Organization of the Study.

The Nature of ADHD

Current research suggests approximately 3-7% of school-age children are affected by ADHD, making it one of the most frequently diagnosed childhood psychiatric disorders (Halperin & Schulz, 2006). ADHD typically manifests in one of three ways (Samuels, 2005). Children can be hyperactive, making it difficult for them to pay attention, follow directions, or sit still long enough to complete a task. They can be inattentive, prone to daydream, and have difficulty paying attention to details. Finally, some children can exhibit both hyperactivity and inattentiveness. All of these factors can greatly affect a student’s performance in the classroom.

Although the most common treatment is the administration of stimulant prescriptions (Arnsten, 2006) such as Ritalin and Adderall (Biederman, Spencer, & Wilens, 2004), approximately 20% of childhood ADHD patients do not respond to stimulant medication (Fox, Tharp, & Fox, 2005). There are also many parents who simply refuse stimulant medication for their children, even though they have no other option for treatment of the ADHD. Some doctors have begun experimenting with non-pharmaceutical treatments for the disorder. However, many of these alternative treatments are costly, controversial, and lack scientific support.
Purpose of the Study

The purpose of this study was to add to the research on non-pharmaceutical alternatives for the treatment of ADHD. Since many have theorized that ADHD is caused by the lack of activity in the prefrontal cortex of the brain (Abraham, Windmann, Siefen, Daum, & Gunturkun, 2006; Szegedy-Maszak, 2002), and studies have shown that brain games can stimulate and increase blood flow to this region (Kawashima et al., 2005), this study sought to determine if the daily use of brain games such as NDSBA can increase the engagement of students with ADHD. It was directed at finding a relationship between the participants’ use of brain games and their level of classroom engagement. Based on the findings, parents, schools, and practitioners who are searching for an alternative treatment for ADHD are provided with some helpful guidance.

Significance of the Study

Approximately two and a half million children take ADHD medication on a daily basis (Phelan, 2006). Many parents and physicians have been on a desperate search for alternative treatments since the United States Food and Drug Administration now mandates that “black box” warning labels be placed on stimulant medications such as Ritalin and Adderall, to warn of possible harmful side effects, such as cardiovascular problems (Nissen, 2006). There is an adequate amount of background research on the prefrontal cortex and its connection to ADHD, and a growing number of studies that accredit brain games with the ability to stimulate this area of the brain, which provides a strong scaffold for this study. However, until this study, the research tying these two variables together has been
extremely limited and inconclusive. The findings of this study provide guidance for parents, teachers, and healthcare professionals who seek an alternative to ADHD medication, and potentially lead to higher achievement for students with ADHD. Additionally, using brain games as an alternative to medication eliminates the possibility of harmful side effects from medication and will save parents a lot of money on prescriptions.

**Definition of Terms**

ADD/ADHD. Attention Deficit Disorder (ADD) is an outdated term for Attention Deficit/Hyperactivity Disorder (ADHD). ADD was previously used in tandem with the clarifiers “with hyperactivity” or “without hyperactivity” to describe patients who were diagnosed with the psychiatric disorder, which is characterized by a variety of inattentive and/or hyperactive behaviors. For the purposes of this study, ADHD, the term currently used by the American Psychiatric Association (1994), was used to refer to the disorder. Although students with ADHD who exhibit hyperactive behaviors were not excluded from this study, the focus remained on the attention and focus deficits that were present.

Beta waves. Beta waves are the fast, irregular brainwaves (12.5-25 HZ) (Clarke, Barry, McCarthy, & Selikowitz, 2002) associated with a state of mental or physical activity (Andreassi, 2000). Children with ADHD often have decreased levels of beta waves in the frontal cortex (Loo & Barkley, 2005), and even more consistently in the posterior regions of the brain (Clarke, Barry, Bond, McCarthy, & Selikowitz, 2002; Dupuy, Clarke, Barry, McCarthy, & Selikowitz, 2011; Leins et al., 2007; Mann, 1990). Approximately 15% of children with ADHD have actually been
found to have excess-beta in the frontal lobe (Clarke, Barry, McCarthy, & Selikowitz, 2001). This subset, consisting primarily of children with combined type ADHD, was found to be similar in behavior to others with ADHD, except more prone to temper tantrums and moodiness. It is believed that alertness, concentration, and cognition are enhanced when beta waves are most abundant (Loo & Barkley, 2005).

**Brain games.** For the purpose of this study, brain games were defined as various tasks or activities designed to strengthen cognitive functions such as memory, problem solving, and rapid mathematics calculation. Such games can be played on a computer, via a hand-held computing device, or even using pencil and paper.

**Electroencephalograph (EEG).** An electroencephalograph (EEG) is an instrument that measures the brain’s electrical activity through electrodes that are placed on the scalp (Nemours, 2010). In this study, an EEG was used to record participants’ beta and theta activity.

**Engagement.** Based on the engagement versus disaffection framework (Skinner & Belmont, 1993), engagement is defined as the prolonged behavioral participation along with a positive emotional attitude. For this study, it served as an indicator of focus, which is one of the main executive functions affected by ADHD.

**Theta waves.** Theta waves are the slow brainwaves (3.5-7.5 HZ) (Clarke, Barry, McCarthy, et al., 2002) associated with a state of drowsiness (Andreassi, 2000). These waves are often more prevalent in children with ADHD, particularly in the frontal and central regions of the brain (Cantor & Chabot, 2009; Clarke, Barry, McCarthy, et al., 2002; Dupuy et al., 2011; Janzen, 1992; Leins et al., 2007; Loo &
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Barkley, 2005). People with ADHD have also been found to have a higher theta/beta ratio than those without ADHD (Clarke, Barry, Bond, et al., 2002; Clarke, Barry, McCarthy, et al., 2002; Monastra, Lubar, & Linden, 2001)

**Theoretical Framework**

Based on the abundance of information on ADHD, when beginning research on a particular treatment, it is necessary to identify a framework suitable for organizing information pertinent to the specific treatment being studied. This study used two frameworks as guides: the executive dysfunction framework (Johnson et al., 2009), and the engagement versus disaffection framework (Skinner & Belmont, 1993). Each framework is introduced below and explained in greater detail in Chapter Two.

The executive dysfunction framework is based on the premise that the symptoms of ADHD are caused by a reduced level of executive control, which is the ability of the brain to regulate cognitive, emotional, and behavioral processes (Johnson et al., 2009). According to this framework, the reduced level of executive control is the result of structural and chemical abnormalities in the pre-frontal cortex of the brain. There is abundant research supporting the theory that ADHD is caused by dysfunction in the brain’s prefrontal cortex (Barkley, 1997; Brennan & Arnsten, 2008; Dickstein et al., 2006; Dige & Wik, 2005). Studies have shown that, as a result, children with ADHD do not perform as well as control students in tests of their executive functions, which are the mental processes that control thinking, emotions, and behavior (Adler et al., 2008; Halperin & Schulz, 2006; Mares et al., 2007). Executive functions are instrumental in focusing, switching focus, and
dividing attention (Johnson et al., 2009). Students with a deficit in these areas find ignoring distractions difficult, and many other functions that support metacognition a challenge (Brown, 2009). The executive dysfunction framework is therefore most suitable for studying symptoms of ADHD that are related to inattention and lack of focus (Johnson et al., 2009).

Engagement, as described by Skinner and Belmont (1993), involves both a student’s behavior and his or her emotions. When comparing engagement to disaffection, the level of a student’s intensity and emotion, associated with the initiation and fulfillment of a learning activity, should be evaluated. Through this lens, prolonged behavioral participation along with a positive emotional attitude is indicative of engagement. Conversely, students who are passive and show little effort are considered disaffected. Because this study ultimately sought to identify a strategy that would help students with ADHD maintain focus, and thus increase their achievement in the classroom, the engagement versus disaffection framework was the most suitable.

Figure 1 depicts the possible relationship between brain games, executive function, and classroom engagement.

**Research Questions**

This study sought to determine if the daily use of brain games such as the Nintendo DS game Brain Age (NDSBA) could increase the engagement of students with ADHD. Qualitative and quantitative data were collected to answer the following sub-questions:
Figure 1. The theoretical framework for this study incorporates the executive dysfunction framework (Johnson et al., 2009) and engagement versus disaffection framework (Skinner & Belmont, 1993; Skinner, Furrer, Marchand, & Kindermann, 2008) to explain how the use of brain games is a possible alternative to prescription medication for the treatment of ADHD, and help improve the classroom engagement of students with ADHD.

1. What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD?

2. What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD?

3. What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD?

4. What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?
5. What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?

6. What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?

Limitations

There are a couple of factors that compromised the validity of the study. Since this study involved a small number of participants, the scope of implications is narrow, which compromises the external validity (Huck, 2008). Compromising the construct validity of the study was the threat of hypothesis guessing (Colosi, 1997), which could have caused a bias in the responses of the participants. Finally, because participants kept a daily journal for a total of seven weeks, the thoughtfulness and detail of their responses appeared compromised over time, and the truthfulness could have been as well, thus posing a maturation threat to the internal validity of the study.

Because the study was not double blind, it is possible that there could have been some personal bias in the researcher’s data analysis and formation of conclusions. The large amount of time the researcher spent interacting with the participants poses a threat to reliability. Additionally, the fact that participants knew they were going to be allowed to keep the Nintendo DS systems at the end of the study could have influenced their reports of engagement.

Other threats include the fact that student engagement on various days could have been affected by outside factors such as mood or class topic. Participant self-reports, as well as parent and teacher reports, are highly subjective and could have
been biased. Also, since the participants were aware that they were involved in an experiment, and it was anticipated that their focus and engagement might increase during the treatment period, it is possible that they reported an improvement due to the fact that they were receiving attention from the researcher, and not necessarily as the result of the brain games. This kind of behavior is often referred to as the Hawthorne Effect (Merrett, 2006). Additionally, although there was not a large amount of missing data, validity was compromised by the gaps that were present. Finally, the sample size of 10 was less than ideal for the statistical analyses that were done. However, it was decided to use the analyses with this in mind, rather than not using them at all.

**Delimitations**

Because many believe the diagnosis of ADHD to be subjective and overused, the selection of participants was limited to the pool of students with a medical diagnosis for primarily inattentive type ADHD or combined type ADHD. Furthermore, only 5th through 11th graders were used as participants for this study. Additional studies will have to be conducted in order to determine if the results can be generalized to early elementary or higher education students, or those with characteristics such as primarily hyperactive type ADHD or previous head trauma.

**Implications**

This study provides guidance to parents, teachers, and practitioners who are in search of a non-pharmaceutical way to help their students with ADHD. It is possible that the use of brain games can ultimately lead to increased performance and achievement for students with ADHD, which can also affect the performance of
other students who are in class with them. Future researchers might seek to
determine which particular types of brain games within the brain game genre are
most effective. Since this study was done using 5th through 11th grade students,
follow-up studies could be done to see if the results are the same for other levels
such as early elementary school or higher education. Additional research could be
done to determine if the treatment is less, more, or as effective for students with
ADHD who take stimulant medication versus those who do not, or students who do
not even have ADHD. Future studies could focus on the duration of the effects, and
provide more detail about how long the games should be played daily, and how
many times per day they should be played. Is it necessary to play the games every
day? Does including weekend play improve the results? Do the treatment effects
remain consistent over months or years of use? Is this kind of treatment more or
less helpful for a particular age group, gender, ethnicity, or ADHD type? Does the
onset of puberty change the effects of brain game play? Do results differ based on
whether the games are played in a secluded location with no distraction versus a
more distracting location? Do those who chose to play of their own will see different
results than those who are forced to play by their parents? This area of research is
so new; there are many possible directions for this research to go.

Organization of Study

This study is presented in five chapters. Chapter I includes the background of
the study, statement of the problem, purpose of the study, significance of the study,
definition of terms, theoretical framework, research questions, limitations,
delimitations, and implications of the study.
Chapter II is a review of literature, which includes an introduction to ADHD, the symptoms of ADHD, the causes of ADHD, the treatments used for ADHD, theoretical frameworks used in this study, and a review of related literature. Chapter III outlines the methodology of this study, including sections on participants, instrumentation, data collection and data analysis.

Chapter IV reveals the findings of the study, including descriptive statistics, results by research question, participant stories, and a summary of the results. Chapter V provides a summary of the complete study, discussion of the findings, implications of the findings as they relate to ADHD theory and practice, recommendations for further research in this area, and conclusions.
Chapter 2: Review of Literature

Attention Deficit-Hyperactivity Disorder

ADHD is a fairly common neurological condition, which manifests in behaviors that are spurred by hyperactivity, impulsivity, and/or inattentiveness (Meletis & Zabriskie, 2008). It is a “chronic disorder that has a negative impact on virtually every aspect of daily social, emotional, academic, and work functioning,” (Ellison, 2003, p. 28). William Still first described the disorder in 1902 (as cited in Brimble, 2009). During previous decades it was referred to as Attention-Deficit Disorder (ADD), qualified by the addition of “with hyperactivity” or “without hyperactivity.” In the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), published by the American Psychiatric Association in 1994, the disorder is officially referred to as ADHD. Additionally, there are three sub-types of the disorder, based on the prevalence of the characteristics.

According to the diagnostic criteria in the DSM-IV (American Psychiatric Association, 1994), in order for a diagnosis of ADHD, Predominantly Inattentive Type to be made, six or more of the following characteristics must be present for at least six months, inconsistent with the person’s developmental level, and cause a disruption to their functioning:

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities
2. Often has trouble keeping attention on tasks or play activities
3. Often does not seem to listen when spoken to directly

4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or lack of understanding instructions)

5. Often has trouble organizing activities

6. Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools)

7. Is often easily distracted

8. Is often forgetful in daily activities

In order for a diagnosis of ADHD, Predominantly Hyperactive-Impulsive Type to be made, at least six of the following characteristics must be present for at least six months, inconsistent with the person’s developmental level, and cause a disruption to their functioning (American Psychiatric Association, 1994):

1. Often fidgets with hands or feet or squirms in seat

2. Often gets up from seat when remaining in seat is expected

3. Often runs about or climbs when and where it is not appropriate
   (adolescents and adults may feel very restless)

4. Often has trouble playing or enjoying leisure activities quietly

5. Is often “on the go” or often acts as if “driven by a motor”

6. Often talks excessively

7. Often blurts out answers before questions have been finished

8. Often has trouble waiting one’s turn

9. Often interrupts or intrudes on others
If criteria for both ADHD, Predominantly Inattentive Type and ADHD, Predominantly Hyperactive-Impulsive Type are met, a diagnosis of ADHD, Combined Type will be made (American Psychiatric Association, 1994). Most children who are diagnosed with ADHD have this type (National Institute of Mental Health, 2008).

At this time, there are no physical tests officially used for diagnosing ADHD, and its diagnosis continues to be made based solely on the criteria listed in the DSM-IV (Shulman, 2009). However, because EEG frequencies give a qualitative and quantitative look at the activity in the brain, this type of technology could be quite useful in the diagnosis of ADHD in the future (Banaschewski & Brandeis, 2007; Loo & Barkley, 2005; Monastra et al., 2001). In children with ADHD, resting EEG activity tends to include increased slow activity and decreased fast activity (Brandeis as cited in Banaschewski & Brandeis, 2007). Since slow activity tends to be most prevalent in the frontal lobes (Cantor & Chabot, 2009; Mann, 1990), this is compatible with the theories that implicate dysfunction in the prefrontal cortex as the cause of ADHD (Brennan & Arnsten, 2008; Dickstein et al., 2006; Dige & Wik, 2005). One study looked at the closed-eye EEG data of 47 participants with ADHD and 7 controls. Using a multi-paradigm method of analysis, which combined nonlinear science, a signal processing technique, and a pattern recognition technique, researchers were able to determine which participants had ADHD in 95.6% of the cases (Ahmadlou & Adeli, 2010). Although parent-, teacher-, and self-rating scales will often be completed to gather information about the DSM-IV criteria as it relates to the person in question, psychologists, psychiatrists,
neurologists, pediatricians, and other medical doctors are the only ones qualified to make an official diagnosis.

**Symptoms**

ADHD is one of the most frequently diagnosed childhood psychiatric disorders (Halperin & Schulz, 2006), with symptoms usually appearing between the ages of 3 and 6 (National Institute of Mental Health, 2008). According to the Center for Disease Control and Prevention (CDC), there are 5 million children in the United States, between the ages of 3 and 17, who have been diagnosed with ADHD at some point in their lives (2009). This accounts for 8% of all American children within this age range. Boys tend to be diagnosed with ADHD more frequently than girls, with 11% of American boys between the ages of 3 and 17 having been diagnosed, compared to only 4.8% of girls the same age. This factor does not necessarily mean that boys are more than twice as likely to have the disorder, but rather more likely to be referred for evaluation due to their higher levels of activity, whereas the symptoms may go unrecognized in girls (Ballard et al., 1997).

For as many as 60% of those diagnosed with ADHD as children, the symptoms will persist into adulthood (CHADD, 2008c; Wiita & Parish, 2008). This translates into approximately 4% of all adults having ADHD. Still, others may not be diagnosed until adulthood. This does not mean they did not have the disorder as a child, but most likely that they just went unnoticed and undiagnosed because they were not as disruptive as others (Resnick, 2005). Symptoms may change from childhood to adulthood, due to maturation and cognitive development.

“Hyperactivity is reduced in adulthood, but impulsivity and other symptoms related
to executive functions typically become more evident as the demands for self-sufficiency increase with age,” (Resnick, 2005, p. 530). The diagnostic criteria are the same for adults as for children, but may need slight modification to better suit the behaviors of adults.

Because of the difficulties the symptoms of this disorder can cause in school, work, relationships, and life in general, early intervention is ideal. In fact by the time they reach the age of 11, 80% of children with ADHD lag at least two years behind their classmates in all critical content areas, and are likely to fail at least one grade by the time they graduate (Brown, 2009). One study looked at the academic development of 1264 participants, ages 4 to 18, over an eight-year period. (GalÈra, Melchior, Chastang, Bouvard, & Fombonne, 2009). Eight years after the study began, participants completed self-reports measuring psychopathology, environmental variables, and academic outcomes. Logistic and linear regression analyses of these reports revealed that childhood hyperactivity-inattentive behaviors had a significant correlation to grade retention (adjusted odds ratio = 3.58, 95% CI = 2.38-5.39, p<0.05), secondary school failure (adjusted odds ratio = 2.41, 95% CI = 1.43-4.05, p<0.05), and receiving a lower-level diploma (adjusted odds ratio = 3.0, 95% CI = 1.84-4.89, p<.05).

In addition to the hardship that can be caused by the symptoms of ADHD, a large number of people with ADHD also suffer from the effects of co-morbid, or coexisting, conditions. Those that most commonly coexist with ADHD are disruptive behavior disorders, mood disorders, anxiety disorders, learning disabilities, and Tourette Syndrome (CHADD, 2003a; Clarke, Barry, McCarthy, et al., 2002; Meletis &
Zabriskie, 2008). In fact, studies indicate that as many as half of those who have ADHD also suffer from another mental disorder such as depression (Antai-Otong, 2008; Meletis & Zabriskie, 2008; Resnick, 2005). Teenagers with ADHD are more likely to smoke and drink excessive amounts of coffee, possibly because the underactive parts of the brain are aroused by the nicotine and caffeine (Resnick, 2005). Furthermore, traffic violations, hospitalizations, emergency room visits, and total medical costs are greater for people with ADHD than those without (Ellison, 2003; Resnick, 2005).

Causes

There have been a myriad of epidemiological studies directed at determining the cause(s) of ADHD. Although no one definitive answer has been found to date, the most validated theories seem to be of a neurobiological and genetic nature (AHC Media LLC, 2007). Neurobiological studies of ADHD can be separated into three categories: neuroanatomical studies, which seek to explain the disorder in terms of brain structure; neurochemical studies, which examine the role of neurotransmitters such as dopamine and norepinephrine; and neurophysiological studies, which attempt to make a connection between the neuroanatomical and neurochemical features of the brain (Ballard et al., 1997; Riccio & Hynd, 1993).

Neuroanatomical research has provided findings that suggest that critical differences in the anatomy of the brain could be responsible for ADHD. For example, positron emission tomographic (PET) scans have shown reduced whole brain utilization of glucose, especially in the right frontal lobe, in patients with ADHD (Riccio & Hynd, 1993). In studies comparing the cerebral blood flow and metabolic
activity of children with ADHD to those without, decreased levels were found in the frontal lobes and basil ganglia of those with the disorder. One study used magnetic resonance imaging (MRI) and found the volume of the frontal lobes and other brain areas to be 3%-4% smaller in children with ADHD (Brennan & Arnsten, 2008; Meletis & Zabriskie, 2008). Additionally, electroencephalographs (EEGs) have provided quantitative data showing elevated theta, or slow wave activity, mainly in the frontal lobes, and decreased beta, or fast wave activity, in the frontal and posterior regions of people with ADHD (Cantor & Chabot, 2009; Clarke, Barry, Bond, et al., 2002; Janzen, 1992; Loo & Barkley, 2005; Mann, 1990; Riccio & Hynd, 1993). Higher theta/beta ratios have also been found in patients with ADHD (Clarke, Barry, Bond, et al., 2002; Clarke, Barry, McCarthy, et al., 2002; Monastra et al., 2001). This implies that arousal in areas of the brain responsible for executive functioning could be deficient in children with ADHD.

The dopaminergic neurotransmitter system has been the focal point of most neurochemical studies of ADHD. The catecholamines, dopamine and norepinephrine, are neurotransmitters that carry messages throughout the brain, particularly to areas that control attention, motivation, and motor functions (Ballard et al., 1997; Brennan & Arnsten, 2008). It has been hypothesized that an imbalance in these chemicals can cause a decrease in the stimulation of the critical parts of the brain, such as the prefrontal cortex, thus leading to many of the symptoms of ADHD (Riccio & Hynd, 1993; Tripp & Wickens, 2008). Results of a recent study showed that the substantia nigra, part of the midbrain, was significantly large, and the
nigrostriatal dopaminergic system abnormal, in patients with ADHD, as compared to the control group without ADHD (Romanos et al., 2010).

Neurophysiological studies are based on the view that neither the neuroanatomical nor neurochemical theory can provide a comprehensive explanation of the complex list of ADHD symptoms. The dysfunction of multiple neural systems could be responsible for the existence of ADHD (Ballard et al., 1997). Additionally, even though much of the ADHD research available focuses on the frontal regions of the brain and executive functioning, there are studies that show the posterior regions and their functions may play a role in the disorder as well (Vaidya & Stollstorff, 2008).

Genetics is commonly accepted as an etiological component of ADHD (Wallis, Russell, & Muenke, 2008). Research has taken a variety of forms such as family, adoption, and twin studies, which have shown that ADHD runs in families and has a genetic element. For instance, one study concluded that between 30% and 35% of the full siblings of probands with ADHD also met the diagnostic criteria for the disorder (Levy, Hay, & Bennett, 2006). Twin studies are a popular choice in the genetic study of ADHD because they allow for the control of many variables. Comparison of monozygotic twins, who share 100% of their genes, to dizygotic twins, who share approximately 50% of their genes, allows estimations to be made regarding whether the presence of certain traits is linked to genetics, shared environmental factors, or non-shared environmental factors. On average, twin studies have indicated that approximately 70-80% of the individual differences of
ADHD can be attributed to genetics, while only 20-30% can be attributed to environmental factors (Wallis et al., 2008).

Adoption studies have been used to look more deeply into the environmental factors that might influence ADHD. “One study found that 6% of the adoptive parents of probands with ADHD had ADHD compared with 18% of the biological parents of probands with ADHD and 3% of the biological parents of the control probands” (Wallis et al., 2008, p. 1089). Environmental factors tend to be more influential when presented early in life, either in utero or immediately after the child is born (Mill & Petronis, 2008). Some of the environmental agents that are considered risk-factors for ADHD are prenatal maternal stress, premature birth, poor maternal prenatal diet, and exposure to nicotine, alcohol, recreational drugs, polychlorinated biphenyls (PCBs), and lead (Mill & Petronis, 2008; Shulman, 2009).

There have also been studies, leading to conflicting conclusions, regarding the impact of nutritional factors, such as food allergies, additives, refined sugar, and essential fatty-acids, on the presence of ADHD (Meletis & Zabriskie, 2008).

**Treatments**

Treatment for ADHD should follow the same basic guidelines for children, adolescents, and adults; it should be “multifaceted and individualized to meet the needs of the patient,” (Resnick, 2005, p. 531). Methods used in treating the symptoms of ADHD can be divided into five basic categories: 1) Medical/medication management, in which medication is used under the supervision of a medical professional, 2) Psychosocial treatment, which focuses on psychological and social components of ADHD through a behavioral approach, 3) Alternative treatment,
which can include any treatment besides prescription medication or standard psychosocial treatments, and usually has minimal published scientific support, 4) Complementary interventions, which have been found by some families to help in the treatment of ADHD symptoms when used in conjunction with prescription medication or standard psychosocial treatments, and 5) Controversial treatments, which are not knowingly supported by scientific publishing and have no acceptable assertions of effectiveness (CHADD, 2008a).

Medication is probably the most widely used treatment for children with ADHD. Its purpose is not to control behavior, but to alleviate the symptoms of the disorder (CHADD, 2003b). Medical doctors are the only ones qualified to prescribe medication (Shulman, 2009). Stimulant medications are the ones most commonly used, as 70-80% of children with ADHD experience success with this type. Approximately two and a half million American students take some form of daily stimulant medication (Phelan, 2006). The theory behind these medications is that they adhere to fundamental neurotransmitters, dopamine and norepinephrine, which are typically in short supply in patients with ADHD. The medications then activate these neurotransmitters in order to stimulate the prefrontal cortex (Szegedy-Maszak, 2002).

The three kinds of stimulant medications most commonly used to improve the symptoms of ADHD are methylphenidates such as Ritalin and Concerta, amphetamines like Adderall, and dextroamphetamine such as Dexedrine (Wolraich, McGuinn, & Doffing, 2007). The most common side effects of stimulant medications like these are a decreased appetite, trouble sleeping, headaches, and irritability or
nervousness. For those for whom stimulant medication is not effective, non-stimulant Atomoxetine, brand name Straterra, is a possible option. Side effects of this medication are decreased appetite, drowsiness, nausea, and abdominal pain. For others, especially adults, antidepressant medications such as Prozac and Zoloft are used as an alternative (CHADD, 2004a). The most common side effects of these medications are insomnia, nausea, and headaches. Although some have postulated that the use of stimulant medication could lead to substance abuse, many longitudinal studies have shown that those who take stimulant medication for ADHD are actually less likely to use or abuse other substances than those who have ADHD and do not take stimulant medication (Meletis & Zabriskie, 2008). In spite of this information, as a result of reports on negative effects such as sudden death in children (Vitiello & Towbin, 2009) and stunted growth (Ptacek, Kuzelova, & Paclt, 2009), some parents are still opposed to stimulant medication.

Psychosocial treatment, otherwise known as behavior therapy and behavior modification, is the only non-pharmaceutical treatment for ADHD that has been supported with a large number of scientific studies (CHADD, 2004b). Behavior therapy involves providing children with ADHD, along with their parents and teachers, strategies for helping improve the child’s behavior. For this, the ABC strategy is often used. This strategy focuses on the Antecedents, which are the things that precede or spark the undesirable behaviors, the undesirable Behaviors themselves, and the Consequences that happen as a result of the behaviors. “Adults learn to change antecedents (for example, how they give commands to children) and consequences (for example, how they react when a child obeys or disobeys a
command) in order to change the child’s behavior (that is, the child’s response to
the command),” (CHADD, 2004b, p. 2). The child’s behavior then changes in
response to the new ways that the adults are speaking to them and reacting to them.

According to CHADD, an ADHD child’s success as an adult depends on the
effectiveness of his mother and father’s parenting skills, his relationships with other
children, and his level of academic success (2004b). Research shows that behavior
therapy can be successful at addressing these critical issues. Behavior therapy often
includes group sessions with a therapist where children work together on their
social skills, since this is an area that is often difficult for those with ADHD. Although
some therapists also see their ADHD patients individually, frequently using doll or
toy play as part of the therapy, these methods have not proven successful in helping
children with ADHD. Prescription medication and behavior therapy are regularly
used in tandem and referred to as multimodal treatment. Studies have shown that
either multimodal treatment or medication alone is more successful at treating the
symptoms of ADHD than behavior therapy alone (Meletis & Zabriskie, 2008).
However, the most recent advice from the National Institute for Health and Clinical
Excellence suggests that behavior therapy should be tried in isolation before
considering taking medication (Brimble, 2009).

Due to concerns about the potential side effects of medication, many parents
turn to alternative therapies to find help for their children with ADHD. However, a
relatively small percent of these parents actually discuss these alternatives with
their pediatrician or family doctor (Sadiq, 2007). This would suggest there is still a
high level of skepticism and uncertainty about many of these treatments. As
mentioned previously, most of them have little published scientific support, which is a good reason for the skepticism. On the other hand, as the research base continues to grow surrounding some of these alternative treatments, they may eventually become integrated into the pool of widely accepted methods.

One alternative treatment method that has been tested for treating ADHD is elimination diets. The Feingold Diet postulates that the elimination of dietary salicylates, and artificially added colors, flavors, and preservatives from a child’s diet could help reduce some of the behavioral symptoms of ADHD (CHADD, 2008a). Although there have been a few studies with positive results in this area, most of them do not support this method of treatment. There have been conflicting findings in studies which have sought to determine if sucrose single-handedly contributes to ADHD (Sadiq, 2007). Most researchers would tend to agree that a diet rich in fiber and nutritious foods is better for the performance and health of any student than a diet full of artificial flavors, preservatives, and sugar. Additionally, there have been quite a few studies that suggest diets that eliminate food allergens help improve the behavior for some students with ADHD. However, there is no conclusive evidence suggesting that any one elimination diet is successful in reducing the symptoms of ADHD for a large number of students.

Dietary supplementation is another area of ADHD alternative treatment constantly under review. A few supplements that have been studied and elicited minimal positive results are magnesium with B6, Ginko Biloba with quinquefolius (Sadiq, 2007), and essential fatty acids such as DHA (Meletis & Zabriskie, 2008; Raz & Gabis, 2009). In spite of these findings, conclusive evidence based on widespread
review of literature in this area suggests that dietary supplements such as these hold very little promise in the treatment of ADHD (CHADD, 2008a).

Massage therapy has also been tried as an alternative treatment to ADHD. In one small study, 28 ADHD patients, with a mean age of 14.6 years, received massage therapy after school for 10 consecutive school days (Field, Quintino, Hernandez-Reif, & Koslovsky, 1998). Following the massage sessions, participants saw themselves as “happier” than their control peers. Additionally, their teachers believed that they were spending more time on classroom tasks during the two weeks of treatment. Another study showed that when 30 ADHD patients between the ages of 7 and 18 years were involved in massage therapy twice a week for a month, there was an immediate, short-term, improvement in their mood, and improved classroom behavior that lasted up to a month (Khilnani, Field, Hernandez-Reif, & Schanberg, 2003). Still, these studies were not large enough to give this type of treatment global credibility.

One emerging treatment that seems to hold a bit more promise is that of EEG biofeedback, more currently referred to as neurofeedback (CHADD, 2008b). During this method, electrodes are placed on the patient’s head. Through video game and/or auditory notification, the patient is given instantaneous feedback regarding his or her brain activity. The premise for this sort of therapy is that the majority of people with ADHD have a surplus of theta, or slow wave activity, and a deficiency in beta, or fast wave activity. Theta waves tend to be indicative of drowsiness or daydreaming, while beta waves are prevalent during times of concentration and problem solving. By training a patient to be conscious of his or her own brain
activity during the treatment, it is believed they will be able to carry this skill over into daily use of their executive functions (Kropotov et al., 2007). Although a meta-analysis of biofeedback studies suggested that EEG biofeedback is “probably efficacious” for the treatment of ADHD (Monastra et al., 2005), more research is needed in this area to determine if the results of this training are transferable to daily tasks. This treatment is not an option that is feasible for most people with ADHD as it requires weekly visits to a clinician, which are not usually covered by insurance companies (CHADD, 2008b). Additionally, research is needed to determine if the EEG is the actual change agent, or if it is the increased amount of time spent with a therapist (Loo & Barkley, 2005).

Although ADHD is not considered a learning disability, its effects can make learning a greater challenge for students (Samuels, 2005). In fact, children and adolescents with ADHD are more likely to have learning disabilities, repeat a grade, be placed in special education, and drop out of school than their peers without the disorder (Raggi & Chronis, 2006). Additionally, as children with ADHD age, their symptoms may get in the way of their social acceptance, causing them to feel left out or alone (CHADD, 2003a). For students with ADHD to overcome these obstacles, their teachers need to be involved in their multimodal treatment along with the student, parents, and doctors. Dupaul and Weyandt devised a set of principles critical to the development of school-based strategies for students with ADHD (2006). First they believe the plan should be a healthy combination of both proactive and reactive strategies. Unfortunately, research shows that teachers tend to rely on reactive punishment as a classroom management strategy rather than
preventative measures that they can then support with positive reinforcement.

Secondly, they believe that “multiple change agents” are necessary to insure that the treatments are implemented consistently. For instance, computer assisted instruction and student self-monitoring may be necessary in situations where teacher-mediated strategies are not as feasible. Finally, they feel that assessment data should guide the planning of treatments, and that a trial-and-error approach is not appropriate. For example, a functional behavior assessment could provide information critical to designing a behavior management plan that better meets the individual needs of a particular student.

There are quite a few interventions that have elicited enough positive research evidence to consider them to be promising options for the school-based treatment of ADHD (Raggi & Chronis, 2006). These include:

1. Classwide peer tutoring and parent tutoring which employ one-to-one instruction, immediate and frequent feedback, and require active responding

2. Instructional and task modifications, which may include allowing students to choose assignments from among several pertinent alternatives, presenting material orally and requiring oral responses in addition to presenting material visually, adding structure or using explicit instructions, employing computer-assisted instruction, and using color or texture to increase stimulation within tasks

3. Classroom functional assessment procedures
4. Self-monitoring and reinforcement, particularly for older children and adolescents

5. Strategy training, including note-taking, study skills, and organizational skills interventions

6. Homework-focused interventions which incorporate goal setting, parent structuring of the homework process, and parent-teacher consultation approaches (pp. 103-104)

Still, more research is needed to help determine the most efficacious school-based interventions for students with ADHD, especially those in the middle and secondary grade levels (Dawson, 2007).

**Frameworks for ADHD Research**

Based on the abundance of information on ADHD, when beginning research on a particular treatment, it is necessary to identify a framework suitable for organizing information pertinent to the specific treatment being studied. Four frameworks or psychological theories that would be appropriate for studying ADHD and its treatments are the State Regulation Model, Delay Aversion, Dynamic Developmental, and Executive Dysfunction (Johnson et al., 2009).

The basis for the State Regulation Model is the idea that children with ADHD have a difficult time remaining in a mental arousal/activation state that is optimal for productivity (Johnson et al., 2009). It is postulated that this state is influenced by the speed at which stimuli are presented. For example, students may attempt to increase their own stimulation, thus becoming more impulsive or hyperactive, when task presentation seems slow to them. On the other hand, if information is
presented too rapidly for a student’s activation state, he or she may become frustrated and give up or lose focus. It can be difficult to study interventions based on this model considering the subjectivity of determining the level of an individual’s activation state. Stimulus presentation that one student may find too fast or too slow may be just right for another student.

Delay Aversion theory is based on evidence that shows that although children with ADHD can wait to respond to a particular stimulus, they do not always want to wait. “It is a motivational account of ADHD, in contrast to theories focusing on cognitive deficits,” (Johnson et al., 2009, p. 5). Some studies have shown that children with ADHD often opt for frequent smaller rewards rather than one larger reward at the end of a delay aversion task (Marco et al., 2009; Sonuga-Barke, Taylor, Sembi, & Smith, 1992). In these studies, participants had to choose between an immediate reward that was less valuable and a more valuable reward that was presented at the end of a longer delay. The results indicate that students who are hyperactive also tend to be more impulsive. Updated versions of this theory suggest that there are separate neural pathways that control choice impulsivity and delay aversion (Sonuga-Barke, 2002, 2003). One study showed that although children with ADHD also have difficulty with inhibition tasks, there is no association between inhibition and delay aversion tasks, supporting the idea of separate neural pathways (Sonuga-Barke, 2002). Delay Aversion theory mainly focuses on impulsivity, which would make it suitable for a study of predominantly hyperactive-impulsive type ADHD. However, since the focus of this study was treatment strategies for combined
type ADHD or predominantly inattentive type ADHD, this framework was not the most suitable.

The Dynamic Developmental Theory (DDT) of ADHD comes from a behaviorist perspective that many of the symptoms of ADHD are influenced by two main behavioral components: “altered reinforcement of novel behavior” and “deficient extinction of inadequate behavior” (Johnson et al., 2009). For children with ADHD, behavioral reinforcers tend to be more effective if they are presented quickly after a desired response to a stimulus. The DDT also attempts to describe the process of how extinction is disrupted in children with ADHD, which is mostly likely caused by the decreased levels of tonic dopamine in the brains of these children. This framework would be useful in studying the behaviors caused by the symptoms of ADHD from a stimulus-response-reinforcement perspective. However, for the purposes of this study, a framework that centers on focus and attention deficiencies was necessary.

Finally, the executive dysfunction framework is based on the premise that the symptoms of ADHD are caused by a reduced level of executive control, which is the ability of the brain to regulate cognitive, emotional, and behavioral processes (Johnson et al., 2009). According to this framework, the reduced level of executive control is the result of structural and chemical abnormalities in the pre-frontal cortex of the brain. There is abundant research supporting the theory that ADHD is caused by dysfunction in the brain’s prefrontal cortex (Barkley, 1997; Brennan & Arnsten, 2008; Dickstein et al., 2006; Dige & Wik, 2005). In 2005, a meta-analysis of 83 Studies, involving a total of 6703 participants concluded that children with ADHD
do not perform as well as controls in tests of their executive functions, which are the mental processes that control thinking, emotions, and behavior (Halperin & Schulz, 2006). Tests that are often used to test executive functions include: verbal fluency tests, where participants have 60 seconds to list proper nouns that begin with a certain letter; verbal fluency for animals, where they have 60 seconds to list as many animals as possible; and multiple element tests that include tasks of simple arithmetic, written picture naming, and dictation (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). The Wisconsin Card Sorting Test, in which participants must determine what rule is being used to sort a stack of cards, is also commonly used in assessing a person’s executive functioning ability. Executive functions are instrumental in focusing, switching focus, and dividing attention (Johnson et al., 2009). Students with a deficit in these areas find ignoring distractions difficult, and many other functions that support metacognition a challenge (Brown, 2009). The executive dysfunction framework is therefore most suitable for studying symptoms of ADHD that are related to inattention and lack of focus (Johnson et al., 2009).

**Engagement**

Merriam-Webster’s Online Dictionary (2010) defines the term engagement as “the state of being engaged,” and the term engaged as “involved in activity: occupied, busy” or “greatly interested.” Still, the term engagement has served a variety of operations in previous research. Pintrich and DeGroot (1990) looked at engagement as a way to evaluate cognitive, meta-cognitive, and self-regulatory strategies used by students. Natriello (as cited in Chapman, 2003b) defined student engagement in terms of participation in school offered programs. In his study,
unexcused absences, damaging school property, and cheating on tests were example
signs of disengagement.

The engagement versus disaffection framework, as described by Skinner and
Belmont (1993), involves both a student’s behavior and their emotions. When
comparing engagement to disaffection, the level of a student’s intensity and emotion
associated with the beginning and completion of a learning activity should be
evaluated. Through this lens, prolonged behavioral participation along with a
positive emotional attitude is indicative of engagement. If engaged, students will
choose tasks that challenge their thinking, show initiative, and exhibit concentration
and effort when given a learning task. Their behaviors will be enthusiastic and
optimistic, and they will appear curious and interested. Conversely, students who
are passive and show little effort are considered disaffected. These students can be
so bored and irritated by classroom requirements that they completely withdraw
from the learning activities and show hostility toward their teachers and peers
(Skinner & Belmont, 1993). If a student is engaged, their ability level will increase,
resulting in higher grades in school and on standardized tests (Skinner, Wellborn, &
Connell as cited in Skinner & Belmont, 1993). Table 1 shows how the engagement
versus disaffection framework encompasses positive and negative, behavioral and
emotional aspects of student engagement.

Since this study sought to identify a means of increasing classroom focus, and
as a result, increase academic performance, the engagement versus disaffection
framework was the one most compatible with the purpose of the study. However,
the question of how to measure this kind of engagement also had to be addressed.
Table 1

*Student Engagement Versus Disaffection (adapted from Skinner et al., 2008)*

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<td>Behavioral</td>
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<td>Enthusiasm</td>
<td>Action initiation</td>
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<td>Interest</td>
<td>Effort/Exertion</td>
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<td>Enjoyment</td>
<td>Attempts/Persistence</td>
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<td>Satisfaction</td>
<td>Intensity</td>
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<td>Pride</td>
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<td>Vitality</td>
<td>Absorption</td>
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There are a variety of methods used to measure student engagement in the classroom. For some studies, work-sample analyses might be most useful since viewing items such as projects and journals can provide the researcher with evidence of higher-order thinking skills (Chapman, 2003b). When the participants of a study are small in number, focused case studies can be used. Data collected using this method will most likely be in the form of field notes describing the settings and interactions of the students being observed.

Self-report, in which the students complete questionnaires about their perception of their own engagement, is the most commonly used method of collecting data on student engagement (Chapman, 2003b). Items might include, but are not limited to, questions about their ability to focus during class instruction or
individual/group tasks, their level of effort during different activities, and their level of enjoyment during various tasks. Prompts can be constructed to elicit quantitative data, qualitative data, or a combination of both. Skinner and Belmont used the Student’s Achievement-Relevant Actions in the Classroom (SARAC), a student self-report of engagement versus disaffection (Skinner, Kindermann, & Furrer, 2009). It is comprised of 20 statements, 5 of each in the areas of behavioral engagement, behavioral disaffection, emotional engagement, and emotional disaffection. Students choose 1 of 4 choices to best describe how they feel about each statement: not at all true, not very true, sort of true, very true (see Appendix A).

Since the ability of students to accurately assess their own thinking and behavior varies (Assor & Connell as cited in Chapman, 2003b), it is advisable to use observer reports as an additional source of data. For this purpose, the SARAC has a teacher-report component that mirrors the format of the student self-report (see Appendix B). The teacher report (TSARAC) is comprised of 20 statements, 4 of each in the areas of behavioral engagement, behavioral disaffection, and emotional engagement, and 8 in the area of emotional disaffection. There are 12 additional statements specific to situations where a difficult problem or assignment is presented, or the student doesn’t do well on a test or assignment. The rating scale is the same as the one for the student SARAC. Additional information about the SARAC is provided in Chapter Three.

A Non-pharmaceutical Alternative?

Although the most common treatment is administration of stimulant
prescriptions (Arnsten, 2006) such as Ritalin and Adderall (Biederman et al., 2004), approximately 20% of childhood ADHD patients do not respond to stimulant medication (Fox et al., 2005). There are also many parents who simply refuse stimulant medication for their child, even though they have no other option for treatment of their ADHD. As discussed earlier, some doctors have begun experimenting with non-pharmaceutical treatments for the disorder. However, many of these alternative treatments are costly, controversial, and lack scientific support.

One relatively new genre of research that is not highly recognized in the literature about ADHD is that of brain games. In 2005, Ryuta Kawashima conducted a study involving 16 experimental and 16 control elderly dementia patients. The experimental group completed learning tasks comprised of standardized basic reading and mathematical problems for approximately 20 minutes per day, 2-6 days a week, for 6 months. To assess the function of the frontal cortex of the brain, the Frontal Assessment Battery (FAB) (Dubois, Slachevsky, Litvan, & Pillon, 2000) was given to all participants prior to treatment, and at the 6-month follow-up. The FAB consists of six verbal prompts that test a participant’s conceptualization, mental flexibility, programming, sensitivity to interference, inhibitory control, and environmental autonomy (see Appendix C). Zero to three points are awarded for each prompt based on the number of errors in the response. If a participant does exactly what the examiner asks for a particular prompt, 3 points will be awarded, for a possible total of 18 points. An independent sample t-Test was run to compare the neuropsychological characteristics of the experimental and control groups, and
evaluate any change in cognitive performance. Results indicated that there was a statistically significant (p < 0.05) increase in FAB scores, from the baseline to follow-up, for the treatment group (7.1 to 8.7), but not for the control group (6.6 to 6.4). There was also a significant difference (p < 0.05) between the follow-up scores for the control group (6.4) and the treatment group (8.7). These findings suggested that learning tasks, or “brain games”, such as those used for treatment in this study, could elicit an increase in prefrontal cortex activity and cognitive function in dementia patients.

Based on Kawashima’s work (2005), companies such as Nintendo have created a new line of brain games. For example, the Nintendo DS game Brain Age (NDSBA) allows users to participate in 10 different games that are modeled after those in Kawashima’s study (Crecente, 2006). Although Kawashima’s study cited other research in which executive dysfunction was blamed for many of the learning difficulties in students with ADHD (Anonymous, 2010; Chapman, 2003a), his methods only tested the benefits of brain games in geriatric patients with dementia. No other published research in the area of using these games to help students with ADHD could be found. This study sought to expand on Kawashima’s research and determine if brain games could help improve the executive functions of students with ADHD as they can for those with dementia.

Based on this literature, it seemed possible that playing brain games such as NDSBA could stimulate the prefrontal cortex of students with ADHD, simulating the effects of stimulant medication, thus helping these students improve their ability to engage in class and perform tasks of executive function. Kawashima believes that
“one possible explanation for the transfer of cognitive functions is the improvement of executive functions” which were a result of the learning activities or brain games his participants completed (2005, p. 383). His research has shown that the use of brain games can help increase activity in the prefrontal cortex of the brain (2005), which is the area of the brain research shows is dysfunctional in those with ADHD (Halperin & Schulz, 2006). Additionally, today’s youth are digitally wired. The things they find most engaging are usually in an electronic format that provides instantaneous audio and/or visual feedback (Wegrzyn, 2008). By presenting brain games to students with ADHD in this format, they are more likely to engage with the games, thus more actively stimulating the critical regions of the brain. Additionally, there are no known negative side effects of brain game use, and it is a relatively affordable and convenient option compared to many of the other alternative treatments.
Chapter 3: Methodology

Research Questions

This study sought to determine if the daily use of brain games such as the Nintendo DS game Brain Age (NDSBA) can increase the engagement of students with ADHD. Qualitative and quantitative data was collected to answer the following sub-questions:

1. What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD?
2. What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD?
3. What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD?
4. What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?
5. What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?
6. What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?

Participants

The 10 participants for this study were chosen from a convenience sample of 5th through 11th grade students with ADHD whose parents had responded to an ad in the local newspaper. Acceptance into the study was made on a case-by-case basis, based on how the individuals fit the parameters of the study. Since this study
focused on the symptoms of ADHD that are related to inattention and other components of working memory, ADHD diagnoses were reviewed, and only those with ADHD, Predominantly Inattentive Type or Combined Type were selected. Although it would have been ideal if none of the participants were taking medication for ADHD at the time of the study, the majority of those who volunteered for the study were taking some sort of medication for this purpose. Six of the ten participants selected were taking medication when the study began. Participants included one female and nine males. The female as well as four other participants were Caucasian. Four of the males were African American, and one was Asian. Ages ranged from 10-17. Table 2 illustrates the demographics of the participants. Greater detail about the participants is provided in Chapter IV.

Table 2

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age</th>
<th>Race</th>
<th>ADHD Type</th>
<th>Meds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>F</td>
<td>16</td>
<td>Caucasian</td>
<td>Inattentive</td>
<td>No</td>
</tr>
<tr>
<td>John</td>
<td>M</td>
<td>12</td>
<td>Asian</td>
<td>Combined</td>
<td>No</td>
</tr>
<tr>
<td>Aaron</td>
<td>M</td>
<td>15</td>
<td>African American</td>
<td>Combined</td>
<td>Yes</td>
</tr>
<tr>
<td>Blake</td>
<td>M</td>
<td>12</td>
<td>African American</td>
<td>Combined</td>
<td>Yes</td>
</tr>
<tr>
<td>Caleb</td>
<td>M</td>
<td>10</td>
<td>Caucasian</td>
<td>Combined</td>
<td>Yes</td>
</tr>
<tr>
<td>Dante</td>
<td>M</td>
<td>13</td>
<td>Caucasian</td>
<td>Combined</td>
<td>Yes</td>
</tr>
<tr>
<td>Eli</td>
<td>M</td>
<td>12</td>
<td>Caucasian</td>
<td>Combined</td>
<td>Yes</td>
</tr>
<tr>
<td>Fynn</td>
<td>M</td>
<td>17</td>
<td>African American</td>
<td>Inattentive</td>
<td>No</td>
</tr>
<tr>
<td>Galen</td>
<td>M</td>
<td>10</td>
<td>African American</td>
<td>Inattentive</td>
<td>No</td>
</tr>
<tr>
<td>Hayden</td>
<td>M</td>
<td>16</td>
<td>Caucasian</td>
<td>Combined</td>
<td>No</td>
</tr>
</tbody>
</table>

An incentive to participate was the possibility of any benefits derived from the daily use of NDSBA. Additionally, participants were allowed to keep the Nintendo DS and Brain Age game at the end of the study. However, they were not aware of what kind of brain game they would be using, or the fact that they would
be allowed to keep it, until after consent forms had been signed. Assent forms were also signed since the participants were minors. Participant pseudonyms were assigned to protect participant identity.

**Instrumentation**

Instruments used to collect quantitative data for this study were the electroencephalograph (EEG), the Student’s Achievement-Relevant Actions in the Classroom (SARAC) (Skinner et al., 2009), the teacher-report SARAC (TSARAC), and the Frontal Assessment Battery (FAB) (Dubois et al., 2000). The researcher-created instruments used to collect qualitative data included participant journal prompts, the Participant Pre-Session Questionnaire, interview questions, a lab observation checklist, parent questionnaires, and questions regarding the cognitive tasks performed during the EEG.

**EEG.** An electroencephalograph (EEG) is a test in which electrodes are placed on the scalp to read the brain’s electrical activity (Nemours, 2010). EEG is considered a reliable and valid source of brain activity data in many disciplines. For example, it has been used to identify variations in, and help classify types of, Epilepsy (Pedley, 2007; Sahin, Ogulata, Aslan, Bozdemir, & Erol, 2008; Sobaniec, Kulak, Bielewicz, & Sobaniec, 2008). It has also been used to evaluate brain damage (Brewer & Perrett, 1971), and monitor the effects of anesthesia on patients (Davidson, 2006; Davidson et al., 2008; Disma, Tuo, Astuto, & Davidson, 2009). More pertinent to this study, it is also used in the psychiatric field to analyze the brain activity of those with ADHD (Clarke et al., 2001; Merkel et al., 2000).
For this study, EEG activity was recorded using BioSemi ActiveTwo equipment (BioSemi B.V., 2011). Using the International 10-20 system of electrode placement (Jasper, 1958), eight channels covering the frontal lobe of the brain were activated: Fp1, Fp2, F3, Fz, F4, C3, Cz, and C4 (see Appendix M), and CMS was used as the ground. Since the ActiveTwo is a monopolar device, it does not have a reference. Common average reference was therefore utilized. Low and high pass filter settings were 0.1 and 70 Hz, respectively, and the EEG sampling was set at 256 Hz. Impedance measurements were not necessary due to the fact that the ActiveTwo system has a preamplifier stage on the electrodes, and can correct for high impedances in the range of 100 kΩ.

Frontal beta and theta activity was recorded using BCI2000 software (Schalk et al., 2004). Beta waves are the fast, irregular brainwaves (12.5-25 HZ) (Clarke, Barry, McCarthy, et al., 2002) associated with a state of mental or physical activity (Andreassi, 2000). Theta waves are the slow brainwaves (3.5-7.5 HZ) (Clarke, Barry, McCarthy, et al., 2002) associated with a state of drowsiness (Andreassi, 2000). Since this study sought to evaluate the overall increase and decrease in theta and beta activity, theta/beta ratio, which has been used in many other EEG studies of children with ADHD, was used (Clarke, Barry, Bond, et al., 2002; Clarke, Barry, McCarthy, et al., 2002; Leins et al., 2007; Monastra et al., 2001). Theta/beta ratio is calculated by dividing the power of the theta band by the power of the beta band. As a point of reference, the researcher considered a study in which 469 participants, ranging from 6 to 20 years in age, participated in four varying tasks while an EEG was conducted (Monastra et al., 2001). For that study, the mean theta/beta ratio for
participants with ADHD was 4.96, while the mean ratio for the control participants was 2.11. This difference in theta/beta ratio between those with ADHD and those without is consistent with the findings of other studies that utilized theta/beta ratio (Clarke, Barry, Bond, et al., 2002; Clarke, Barry, McCarthy, et al., 2002).

**SARAC and TSARAC.** The Student’s Achievement-Relevant Actions in the Classroom (SARAC) is a student self-report of engagement versus disaffection (Skinner et al., 2009). It is comprised of 20 statements, 5 of each in the areas of behavioral engagement, behavioral disaffection, emotional engagement, and emotional disaffection. Students choose one of four choices to best describe how they feel about each statement: not at all true, not very true, sort of true, very true (see Appendix A). Since the ability of students to accurately assess their own thinking and behavior varies (Assor & Connell as cited in Chapman, 2003b), it is advisable to use observer reports as an additional source of data. For this purpose, the SARAC has a teacher-report component that mirrors the format of the student self-report (see Appendix B). The teacher-report (TSARAC) is comprised of 20 statements, 4 of each in the areas of behavioral engagement, behavioral disaffection, and emotional engagement, and 8 in the area of emotional disaffection. There are 12 additional statements specific to situations where a difficult problem or assignment is presented, or the student does not do well on a test or assignment. The rating scale is the same as the one for the student SARAC.

To determine the validity of both the student-report and teacher-report components of the SARAC, 1018 3rd through 6th graders participated in a four-year longitudinal study about student motivation (Skinner et al., 2009). Fifty-three of the
students’ teachers also participated in the study. Data from the fall and spring administrations of year three was utilized. When comparing engagement versus disaffection, correlations between student-reports and teacher-reports were significant in both the fall \( r = .41, p < .01 \) and spring \( r = .42, p < .01 \). Based on Cohen’s effect size criteria (Cohen, 1992), these results suggest a medium to large relationship between student and teacher reports \( (r^2 \text{ values of .17 and .18 respectively}) \), which strengthens the concurrent validity of the instruments.

Correlation between the four components of the engagement versus disaffection framework showed that emotion and behavior were positively correlated (average \( r = .60; p < .001 \)), while engagement and disaffection were negatively correlated (average \( r = -.52; p < .001 \)). Table 3 provides additional information about the correlations. These relationships provide construct validity for the SARAC. For this

Table 3

<table>
<thead>
<tr>
<th>Student-report</th>
<th>Behavioral Engagement</th>
<th>Behavioral Disaffection</th>
<th>Emotional Engagement</th>
<th>Emotional Disaffection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Engagement</td>
<td>---</td>
<td>-.55</td>
<td>.60</td>
<td>-.45</td>
</tr>
<tr>
<td>Behavioral Disaffection</td>
<td>-.42</td>
<td>---</td>
<td>-.52</td>
<td>.67</td>
</tr>
<tr>
<td>Emotional Engagement</td>
<td>.53</td>
<td>-.41</td>
<td>---</td>
<td>-.60</td>
</tr>
<tr>
<td>Emotional Disaffection</td>
<td>-.34</td>
<td>.61</td>
<td>-.51</td>
<td>---</td>
</tr>
</tbody>
</table>

Note. \( N = 1018 \) students. Correlations for fall are below the diagonal; correlations for spring are above the diagonal. All correlations were statistically significant \( (p < .001) \).
study, the same researcher administered and evaluated the SARAC for all of the participants to eliminate any concern regarding interrater reliability.

**FAB.** The FAB is a frontal assessment battery created by Dubois and associates (2000) to assess the functions of the frontal lobe of the brain in order to help diagnose executive dysfunction. The FAB consists of six verbal prompts that test a participant’s conceptualization, mental flexibility, programming, sensitivity to interference, inhibitory control, and environmental autonomy. Zero to three points are awarded for each prompt based on the number of errors in the response (See Appendix C). If a participant does exactly what the examiner asks for a particular prompt, 3 points will be awarded, for a possible total of 18 points. The test takes approximately 10 minutes to administer.

To determine the validity and reliability of the FAB, 121 patients with varying degrees of frontal lobe dysfunction, and 42 controls with no neurologic or psychiatric history, were given the FAB as well as the Mattis Dementia Rating Scale (DRS) and Mini-Mental State Examination (MMSE) (Dubois et al., 2000). The Wisconsin Card Sorting Test (CST) was also given to 86 of the participants with frontal lobe dysfunction. A correlation was found between the FAB and DRS scores in 121 patients ($r = 0.82$, $p < 0.001$). Based on Cohen’s effect size criteria (Cohen, 1992), these results suggest a medium to large relationship between student and teacher reports ($r^2$ values of .17 and .18 respectively). It was also found that the DRS scores and number of criteria achieved in the CST accounted for 79% of variance in the FAB ($F [2,82] = 152.9; p < 0.001; r^2 = 0.79$). These results helped establish concurrent validity. An ANCOVA showed that the FAB discriminated between
controls and patients after adjusting for age as a covariate (analysis of covariance: \( F[1,131] = 17.24; p < 0.001 \)) (Dubois et al., 2000).

In the same research (Dubois et al., 2000), performance on the FAB correctly identified 89.1\% of the cases, based on Wilk’s lambda (\( \Lambda = 0.43, F[1,135] = 176.2; p < 0.001 \)). Discriminant validity was strengthened based on these results. Additionally, the FAB showed considerable interrater reliability based on the comparison of results from two independent evaluators, for a subset of 17 patients (\( k = 0.87, p < 0.001 \)). The Cronbach’s coefficient alpha between the items of the FAB of 121 patients was 0.78, which suggests good internal consistency.

The FAB was also used with children aged 5-14 in an Italian study (Scarpa et al., 2006). In this study, the FAB and two other instruments were standardized on 283 normally developing participants to subsequently use in assessing impaired cognitive functions of those with epilepsy. By the age of nine, a stepwise performance progression seemed to level off with most of the participants this age or older reaching at or near 100\% correctness on the FAB. “This trend, showing that control processes gradually consolidate, seems to be related to the anatomical development of the frontal cortex, which is known to occur in this period” (Scarpa et al., 2006, p. 392).

**Journal prompts.** Participants kept a daily electronic journal for the duration of the study. Journal entries should have included the treatment period of five weeks from February 28 through April 1, and the post-treatment period of two weeks from April 11 through April 22. Participants were told they did not need to write journal entries on the weekends or during spring break, which was April 4-8.
To ensure that journal entries provided information regarding the participants’ focus at school that was consistent with the study’s theoretical framework, prompts were designed based on Skinner and Belmont’s engagement versus disaffection framework (Skinner et al., 2009) (see Appendix D). Participants were asked to describe how they “felt” at school that day, and were provided with examples from Skinner and Belmont’s framework, that were indicative of emotional engagement and emotional disaffection. They were also asked to describe how they “behaved” at school that day, and were provided with examples from the framework that were indicative of behavioral engagement and behavioral disaffection. Additionally, they were asked to identify if these feelings and behaviors were true for all classes or just some, and which ones. They were also asked to identify any outside factors that might have affected their engagement during the day, and were given examples such as “forgot to eat breakfast” and “really interested in a particular topic.” Additional information elicited by the journal prompts included whether or not they played the brain games that morning, for how long, and the reason why, if they did not play. Finally, they were asked to write about anything else that came to mind regarding their attitude about, and behavior at, school that day.

**Participant pre-session questionnaire.** Participants completed a Participant Pre-Session Questionnaire when they arrived for their first session (see Appendix E). The goal of this questionnaire was to collect data about outside factors that might affect their mental processing and focus. It included questions concerning consumption of medication, caffeine, and nicotine. Prompts regarding the participant’s level of video game play, prior occurrences of brain injury,
meditation/relation rituals, and level of athleticism were also used. It was stated in the consent form, which was signed prior to the completion of this questionnaire, that those using illegal substances could not participate in the study, due to the probability that these substances would affect the EEG data, making it unreliable. Therefore it was not necessary to include a prompt regarding that topic in this questionnaire.

**Interviews.** Participants were interviewed by the researcher during the post-treatment and follow-up sessions. The questions in the post-treatment interview were open-ended and were directed at gathering details about the five weeks of treatment (see Appendix F). Participants were asked questions about frequency of play, effort exerted during play, level of outside distraction while playing, and enjoyment resulting from play. Participants were also asked to identify any difference they had noticed in their ability to focus at school or engage in class during the treatment period, and what they predicted would happen during the following two weeks of school when they would not be playing the game. Participant responses to the interview questions provided verification of the information provided in their journal entries, which increased the trustworthiness of the data.

The questions used in the follow-up interview (see Appendix G) were open-ended and were directed at gathering details about the three post-treatment weeks (Spring Break, followed by two weeks of school). One question was included to confirm that the participant had not played any sort of brain games post-treatment. As in the post-treatment interview, participants were asked to identify any difference they had noticed in their ability to focus at school or engage in class
during the post-treatment period, as well as any other difference they had noticed in their behavior or symptoms of ADHD during that time. Additionally, participants were asked to give their opinion regarding the use of brain games as treatment for symptoms of ADHD, and whether or not they intended to resume the use of the games post-study.

**Observation checklist and field notes.** During all three sessions, the researcher recorded any observance of the indicators of engagement and disaffection using Table 1 as a checklist. General field notes were also recorded during each session. The inclusion of observer data added to the trustworthiness of the data from participant journal entries and interview responses.

**Parent questionnaires.** Parents completed pre-treatment, post-treatment, and end of study questionnaires. Prompts on the pre-treatment questionnaire were directed at gathering historical information regarding the participant’s experience with ADHD (see Appendix H). Parents were asked to indicate when they first noticed signs of ADHD in their child, what those signs were, and how long they waited to see a healthcare professional regarding their observations. They were also asked what methods of treatment they had tried up to that point, and their reasons for discontinuing any of those treatments. Additionally, they were asked to share their greatest concerns regarding their child’s ADHD, and what they hoped would happen as a result of their child’s participation in the study. Finally, they were asked to provide any other information that might be helpful or interesting to the researcher.
Prompts on the parent post-treatment questionnaire were directed at gathering information regarding the five weeks of treatment (see Appendix I). As another method of validating the participant-report data, parents were asked to confirm, based on their observations, whether the participant played the game daily, and whether they remembered on their own or had to be reminded. They were then asked about any changes they had noticed in the participant’s behavior/attitude and school performance during the treatment period, and if there were any, when the changes started to occur. The remaining prompts elicited their opinion about the use of the games at this point, and whether or not they planned for their child to resume use of the games once the study was over. As with the pre-treatment questionnaire, they were given a space to share any other thoughts they had regarding the study.

The questions on the parent follow-up questionnaire were designed with two purposes in mind: collect information regarding the three post-treatment weeks, and determine the parents’ overall opinion of brain games as an alternative treatment for ADHD (see Appendix J). Specifically, they were asked to identify any changes in behavior/attitude or school performance they had noticed since their child stopped playing the brain games, and if there were any, to specify when they noticed the changes. They were also asked if their opinion about the use of the games had changed during the post-treatment period, and whether or not they planned for their child to resume the use of the games at that point. As with the first two parent questionnaires, they were asked to share any other thoughts or suggestions they might have regarding this topic.
Video and reading questions. Participants also answered questions (VQ/RQ) about each video watched or selection read during the EEG (see Appendixes K and L). There were five prompts following each cognitive task. Scores from these tasks were used as an indicator of executive function, by showing the ability of participants to focus on details, switch tasks, and tune out distractions.

NDSBA data. The researcher retrieved the following data from the NDSBA of each participant: the dates Brain Age was played, the number of days at least three games were played, and how many times each individual game was played during the treatment period. The researcher also retrieved the data that showed how many times participants checked their “Brain Age” during the treatment period. These features are explained in greater detail in the treatment section. Data collected from the participants’ Nintendo DS units was used to confirm or refute the information provided in the individual participant journals and interviews.

Design

For this study, a mixed methods approach was used (Lunenburg & Irby, 2008). This allowed the research questions to be answered with the reliable paradigm picture of a qualitative multiple case study design (Creswell, 2008), while utilizing the quantitative paradigm to dig deeper into a few aspects of the study: executive functioning as measured by the FAB, student-reported and teacher-reported engagement as measured by the SARAC, and levels of beta and theta measured by the EEG. It is the belief of pragmatists that there is a “false dichotomy” between these two paradigms, and that it can be more effective if the two are used together (Creswell, 2008). Including a quantitative piece, in the form of a repeated-
measures design (Levine & Parkinson, 1994), added precision to the study by including numerical data that could be statistically manipulated.

Probably the strongest reason for choosing this approach was to ensure triangulation (Gallivan, 1997). Bias can be reduced or eliminated from one source by combining it with the data from other sources. In other words, triangulation is a way of seeking agreement in the findings. For example, to answer research question two regarding participant self-reported engagement, participant journals and interviews were used, as well as the SARAC. For participants whose SARAC scores supported their journal entries and interviews, the trustworthiness of their responses was increased. If a participant’s SARAC scores were not in correspondence with his or her qualitative pieces, then the reasons why were called into question. Additionally, data collected for the six research questions could be compared to look for relationships. For instance, how did the change in theta/beta ratios relate to the change in FAB or VQ/RQ scores? How were the participant, observer, parent, and teacher reports similar or different? The utilization of five quantitative instruments and five qualitative instruments allowed for a comprehensive assembly of results.

**Data Collection**

**Overview.** For this study, the majority of the data was collected during the three lab sessions. During the pre-treatment lab session, data was collected in the form of researcher observations, and from administration of the FAB, SARAC, EEG, participant pre-session questionnaire, parent pre-treatment questionnaire, and VQ/RQ. During the post-treatment lab session, data was collected in the form of researcher observations, and from administration of the FAB, SARAC, EEG,
participant post-treatment interview, parent post-treatment questionnaire, and VQ/RQ. Additionally at this session, the pre-treatment and post-treatment TSARAC forms were collected from participants if the teachers had not already mailed them directly to the researcher. Finally, during the follow-up lab session, approximately three weeks after the post-treatment meeting, data was collected in the form of researcher observations, and from administration of the SARAC, EEG, participant follow-up interview, parent follow-up questionnaire, and VQ/RQ. Additionally at this session, the follow-up TSARAC forms were collected from participants if the teachers had not already mailed them directly to the researcher. Supplementary data was collected during the treatment period in the form of participant journals, which were submitted to the researcher at the follow-up lab session.

**Pre-treatment lab session.** Individual pre-treatment lab sessions were scheduled at the participants’ convenience, and were completed over a four-day period. Each individual lab session lasted approximately 1.5 hours and began with the participants and their parents signing the required consent and assent forms. Before the parents were dismissed to the waiting area, sessions two and three were scheduled, participant demographic information was recorded, and parents were given a folder containing forms that would be completed by the parents and teachers throughout the study. Parents completed the parent pre-treatment questionnaires while their children completed their lab sessions. The post-treatment questionnaire to be completed the day of session two and the follow-up questionnaire to be completed the day of session three were also included in the folder. Additionally, the folder contained three sets of the TSARAC: one set that was
to be distributed to the participants’ teachers immediately for completion, one set to
distributed and completed at the end of the treatment period, and one set to be
distributed and completed after the participants had stopped playing the brain
games for three weeks. The parents were dismissed to the waiting area for the
remainder of the session, and the researcher started the digital video recorder. The
researcher used a checklist, shown in Figure 2, to ensure that all pre-treatment
session procedures were completed in the same order for each participant.

The Participant Pre-session Questionnaire (see Appendix E) was the first
instrument to be completed. The researcher went over each prompt with the
participants to ensure they understood what the questions were asking. Prior to
being dismissed to the waiting area, the parents provided information regarding the
type of ADHD with which the participants had been diagnosed. If the participants
had questions while completing the questionnaires, the researcher could open the
door to the waiting area and ask the parents for assistance.

Next, the FAB was administered in order to evaluate the participants’ current
level of executive functioning. This process was digitally recorded for each
participant so the researcher could review physical behaviors during the analysis
phase, and scoring of the instrument could be done at a later time if needed. The
procedures for administration of the FAB are spelled out clearly on the instrument
itself (see Appendix C). Once the researcher was finished administering the FAB to a
participant, the digital video recorder was stopped. This was to ensure that there
was enough battery power and storage space on the camera to record all
participants during the administration of the Participant Pre-session Questionnaire.
Pre-treatment Session Checklist

--- introductions
☐ signed consent form(s)
☐ signed assent form
☐ schedule sessions 2 & 3
☐ demographic info (double check all info. on contact sheet)
☐ give parent/teacher forms to parent
--- dismiss parent (complete parent quest. while waiting)
--- start video camera
☐ Participant Pre-session Questionnaire
☐ Frontal Assessment Battery (FAB)
--- EEG preparation
☐ Reading/Questions (1st for 1,3,5,7,9)
☐ Video/Questions (1st for 2,4,6,8,10)
--- Disconnect from EEG
☐ SARAC
--- readmit parent (explain not to correct student Bx)
☐ collect parent questionnaire
☐ setup and training on DS
☐ flash drive / journal prompts
--- questions...

Figure 2. Checklist used by the researcher in the pre-treatment session.

and FAB. Additionally, it was unnecessary to record the remainder of each lab session since the participants would be trying to sit as still as possible for the EEG, would not be talking, and would be facing away from the camera.

Following the FAB, participants were prepared for the EEG, which included fitting them for the correct size cap, filling the electrode ports with an electricity conducting gel, and snapping the electrodes into the proper ports. Using the
International 10-20 system of electrode placement (Jasper, 1958), eight channels covering the frontal lobe of the brain were activated: $F_{p1}$, $F_{p2}$, $F_3$, $F_2$, $F_4$, $C_3$, $C_Z$, and $C_4$ (see Appendix M). BCI200 software (Schalk et al., 2004) was used to process the signals from the EEG. It was programmed by the lab director to record for approximately 3.5 minutes at a time, to ensure it had adequate time to collect signal information. If the participant took less time for a particular activity, the recording could be paused manually.

All participants completed two sets of activities while connected to the EEG. Random selection determined which set of activities each participant would do first. For one set of activities, participants watched approximately eight minutes of *The Voyage of the Mimi* (Bank Street College of Education, 1984), which was an educational television series used by many states in the 1980s as part of the middle school science curriculum. This video was chosen to ensure that the participants had not previously viewed the video. They watched the first half of the video while the EEG was collecting data. Participants were instructed to sit very still so that the EEG would not pick up physical movement. The EEG was paused, and they were given five questions to answer about the video. The EEG was resumed, and participants watched the second half of the video while the researcher provided extraneous stimuli in the form of a pen clicking at specified time intervals determined and indicated by the EEG software. Any time the EEG was active, an arrow flashed at random time intervals and durations on a second monitor, indicating the instances that the EEG was actually recording. The participants could not see this monitor. During the activities involving distraction, the research used
the arrow on the screen as a cue to provide distraction. Since this was not done in a regular pattern, the participants could not anticipate when the distraction was coming. The purpose of adding the distraction for the second half of the activity was to evaluate the participants' ability to tune out distractions, and see if there was any EEG evidence of the distraction.

Again, the EEG was paused and they were given five questions to answer about the second half of the video. EEG data was collected only during the actual viewing of the videos, not during the answering of the questions. The purpose of the question and answer check was to ensure that participants were actually paying attention to the video, and hopefully attending closely enough to answer questions about what they saw. For the remainder of this study, this set of activities will be referred to as Video/Question (VQ). Individual videos will be differentiated by the terms with distraction or without.

The second set of activities was completed in the same manner as the VQ. When the EEG was restarted, participants read a short selection from *Incredible Animal Adventures* (George, 1999), a book of nonfictional short stories, written on a sixth grade reading level. The EEG was paused and they were given five questions to answer about the selection. The EEG was resumed, and they read a second selection from the same book while the researcher provided extraneous stimuli in the form of crackling a plastic water bottle at specified time intervals determined and indicated by the EEG software. For the remainder of this study, this set of activities will be referred to as Read/Question (RQ). Individual reading selections will be differentiated by the terms with distraction or without.
Participants who were assigned to complete the RQ first and then the VQ had the clicking pen as a distraction during the RQ and the bottle noise as a distraction during the VQ. Six different distractors were used throughout the study so that participants would not get used to one particular distraction, and possibly be more able to tune it out over time. Each of the distractors was something that could be heard in a typical classroom environment. Additionally, random assignment determined which of the RQ selections they read first within that activity. This was the case for all three lab sessions. EEG data was collected only during the actual reading of the selection, not during the answering of the questions. Again, the purpose of the question and answer check was to ensure that participants were actively reading, and hopefully attending closely enough to answer questions about what they read. After the VQ and RQ the participants’ EEG caps were removed and disconnected. During the entire lab session, the researcher observed the behavior of the participants, using Table 1 as a checklist to record signs of engagement and disaffection. General field notes were recorded as well.

Next, participants completed the student-report SARAC. They were told that it would not be shown to anyone, and they should be as honest as possible regarding their feelings about school and behaviors at school. Participants were asked to distribute copies of the TSARAC, given to the parents at the beginning of the session, to their teachers on the Monday following the pre-treatment session, and were asked to request the completion of these questionnaires by their teachers. They were then returned to the participant in pre-addressed, sealed envelopes to be
returned to the researcher or mailed directly to the researcher’s office by the teachers.

The parents were invited back into the lab, and the parent pre-treatment questionnaire was collected. They were asked to remain in the lab while the researcher explained the journaling system and the brain game. Participants were asked to keep an electronic daily journal about their experience using the NDSBA and their classroom engagement. Participants were assigned jump drives containing their journal prompts and pre-dated electronic journals for their use. They were given the option to write their journal entries in a provided pre-dated spiral notebook, but all participants chose to use a computer instead. While the participants watched, the researcher loaded the journal and went over the prompts and the process to ensure the participants understood what was being asked of them. Before leaving, participants were assigned a Nintendo DS and a copy of the compatible Brain Age software, and were instructed how to use it. More information about the treatment is provided in the following section. During the entire lab session, the researcher observed the behavior of the participants, using Table 1 as a checklist to record signs of engagement and disaffection. General field notes were recorded as well.

**Post-treatment lab session.** Upon completion of the treatment period of five weeks, participants returned for individual lab sessions that were approximately an hour each. These were completed over a period of three days. When participants arrived, they gave the researcher their case containing the Nintendo DS and Brain Age game since they would not be allowed to play it for the
next three weeks. The parent post-treatment questionnaire was collected, as well as any TSARAC forms that had been returned to the participants. Some teachers mailed them directly to the researcher at her university mail drop. The original plan called for the participants to collect all of the teacher forms in order to ensure that they did not forget to fill them out or mail them. However, some of them insisted on sending them directly to the university.

Parents were dismissed to the waiting area, and the digital video recorder was started. The researcher used the questions from the post-treatment interview (see Appendix F) to guide a discussion regarding the five weeks of treatment. These interviews took approximately five minutes each. Prompts included questions about frequency of play, effort exerted during play, level of outside distraction while playing, and enjoyment resulting from play. Participants were also asked to identify any difference they had noticed in their ability to focus at school or engage in class during the treatment period, and what they predicted would happen during the following two weeks of school when they would not be playing the game. Additionally, they were given the opportunity to share any other information they felt was important to the study. The researcher was extremely careful not to lead the participants into answering a certain way, and read the questions as stated. They were asked to tell the truth, not what they thought the researcher wanted to hear. In cases where a participant’s answer was short or lacked detail, the researcher asked for elaboration. In some instances it was necessary for the researcher to ask for clarification of a statement.
Procedures for administration of instruments followed the same order and detail as in the pre-treatment session. As during the pre-treatment session, the researcher used a checklist, shown in Figure 3, to ensure that all post-treatment session procedures were completed in the same order for each participant.

<table>
<thead>
<tr>
<th>Post-treatment Session Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>--- check-in (make sure they played NDSBA today)</td>
</tr>
<tr>
<td>□ collect NDS, Brain Age, case, and charger</td>
</tr>
<tr>
<td>□ download journal entries from flash drive and return</td>
</tr>
<tr>
<td>□ collect any parent / teacher questionnaires</td>
</tr>
<tr>
<td>--- start video camera</td>
</tr>
<tr>
<td>□ interview questions</td>
</tr>
<tr>
<td>□ Frontal Assessment Battery (FAB)</td>
</tr>
<tr>
<td>--- stop video camera</td>
</tr>
<tr>
<td>--- EEG preparation</td>
</tr>
<tr>
<td>□ Reading/Questions (1st for 1,3,5,7,9)</td>
</tr>
<tr>
<td>□ Video/Questions (1st for 2,4,6,8,10)</td>
</tr>
<tr>
<td>--- Disconnect from EEG</td>
</tr>
<tr>
<td>□ SARAC</td>
</tr>
<tr>
<td>□ go over expectations for the next 3 weeks</td>
</tr>
<tr>
<td>--- questions...</td>
</tr>
</tbody>
</table>

*Figure 3. Checklist used by the researcher in the post-treatment session.*

The FAB was administered, the digital video camera turned off, and the participant prepared for the EEG. Participants completed the VQ and RQ activities in the same order that they had been randomly assigned to during the pre-treatment session. The video was a different episode from *The Voyage of the Mimi* series (Bank Street College of Education, 1984), and approximately ten minutes long. The
readings were two different stories from *Incredible Animal Adventures* (George, 1999). The distraction provided during the second half of the first activity was a clicking eraser. During the second half of the second activity, the researcher thumbed a stack of index cards for distraction. After the VQ and RQ, the participants' EEG caps were removed and disconnected.

Participants completed their second copy of the student-report SARAC. Again, they were told that it would not be shown to anyone, and they should be as honest as possible regarding their feelings about school and behaviors at school during the five weeks of treatment. At the close of the session, the researcher explained to the participants and parents the expectations for the following three weeks. They were asked not to play any kind of brain game during the next three weeks. All participants had Spring Break week immediately following their post-treatment sessions and did not attend school during that week. They were told that they did not have to write journal entries for that week, but did need to write in their journals during the two weeks of school following Spring Break even though they would not be playing brain games. They were also told they would submit their jump drive containing their journal when they returned for the final session, and that they should bring the parent follow-up questionnaire along with any TSARAC forms that were returned to them. As with the pre-treatment session, the researcher observed the behavior of the participants throughout the session, using Table 1 as a checklist to record signs of engagement and disaffection. General field notes were recorded as well.
During the three weeks between the post-treatment and follow-up lab sessions, the researcher retrieved participant data from the NDSBA software installed on each game unit. As described earlier, this data provided the specifics about each participant’s interaction with the brain games, including which dates they played, and more specifically, the dates that they played at least three games. Additionally, the researcher recorded how many times participants played each game, and completed the brain age check, during the treatment period.

**Follow-up lab session.** Following the three weeks of non-use of the brain games, participants returned for their final individual lab sessions that were approximately an hour each. These were completed over a four-day period. When participants arrived, they gave the researcher their jump drive containing their journal. The parent follow-up questionnaire was also collected, as well as any TSARAC forms that had been returned to the participants. Again, some teachers mailed them directly to the researcher at the university. As done previously, the researcher used a checklist, shown in Figure 4, to ensure that all follow-up lab session procedures were completed in the same order for each participant.

Parents were dismissed to the waiting area, and the digital video recorder was started. The researcher used the questions from the follow-up interview (see Appendix G) to guide a discussion regarding the three weeks since stopping the treatment. These interviews took approximately five minutes each. Prompts included one question to confirm that the participant had not played any kind of brain games since stopping the treatment three weeks prior to the final lab session. As in the post-treatment interview, participants were asked to identify any
Follow-up Session Checklist

--- check-in
☐ collect flash drives
☐ collect any parent / teacher questionnaires
--- start video camera
☐ interview questions
--- stop video camera
--- EEG preparation
☐ Reading/Questions (1st for 1,3,5,7,9)
☐ Video/Questions (1st for 2,4,6,8,10)
--- Disconnect from EEG
☐ SARAC
☐ return NDS, Brain Age, case, and charger
☐ Who is going to resume use?
   Willing to provide updates?
☐ If time allows, give brief overview of data
--- questions...

Figure 4. Checklist used by the researcher in the follow-up session.

difference they had noticed in their ability to focus at school or engage in class during the post-treatment period, as well as any other difference they had noticed in their behavior or symptoms of ADHD during that time. Additionally, they were asked to give their opinion regarding the use of brain games as treatment for symptoms of ADHD, and whether or not they intended to resume the use of the games post-study. Additionally, they were given the opportunity to share any other information they felt was important to the study. Again, the researcher was very careful not to lead the participants into answering a certain way, and read the questions as stated. They were asked to tell the truth, not what they thought the
researcher wanted to hear. In cases where a participant’s answer was short or lacked detail, the researcher asked for elaboration. In some instances it was necessary for the researcher to ask for clarification of a statement. The digital video recorder was stopped at the end of the interview. The FAB was not administered during the follow-up session due to the recency of its previous administration and the chance that the practice effect (Huck, 2008) would influence the results, having already been administered twice.

Participants were prepared for the EEG. Procedures for the VQ and RQ followed the same order and detail as in the first two sessions. Participants completed the VQ and RQ activities in the same order that they had been randomly assigned to during the pre-treatment session. The video was a different episode from The Voyage of the Mimi series (Bank Street College of Education, 1984), and approximately ten minutes long. The readings were two different stories from Incredible Animal Adventures (George, 1999). During the second half of the first activity, the researcher shook a bottle of correction fluid containing mixing beads for distraction. For distraction during the second half of the second activity, the researcher rattled a plastic case containing refill pencil lead.

Participants completed their third copy of the student-report SARAC. As with the first two administrations, they were told that it would not be shown to anyone, and they should be as honest as possible regarding their feelings about school and behaviors at school during the three weeks since stopping treatment. In several cases, there was extra time between sessions, and the researcher had a chance to talk with the participants’ parents regarding their overall feelings about the study.
Before leaving, the participants were given the Nintendo DS and Brain Age game to keep. As with the pre-treatment and post-treatment sessions, the researcher observed the behavior of the participants throughout the session, using Table 1 as a checklist to record signs of engagement and disaffection. General field notes were recorded as well.

**Treatment**

**Nintendo DS Brain Age.** Participants were assigned a Nintendo DS system and a copy of Brain Age software (Nintendo, 2005). Participants were also provided with sound isolation ear-buds to help them block out distractions from their surroundings while playing the game. Participants were asked to play a minimum of 20 minutes each morning before school, but told they could play longer as long as they noted it in their daily journal. They were not required to play on the weekends, but were allowed to do so, as it would be noted by the researcher when retrieving the data from the Nintendo DS units. Treatment continued for five weeks. Data regarding the dates played and number of times specific games were played during the course of the treatment period was retrieved from the units by the researcher during the three weeks that the participants did not have them. This allowed the researcher to verify the frequency and duration of utilization.

To play NDSBA, participants held the Nintendo DS unit sideways compared to most other games made for this game system (see Figure 5). The problems or prompts were given on the left screen of the dual-screen device, and answers were entered on the right touch-screen using a stylus. For the one left-handed participant in the study, the orientation was reversed.
After each game was completed, a total score, which was a combination of time used and incorrect responses, was given on the left screen. On the right screen, the participant’s top three scores for that game were displayed. On the next screen the results for that attempt were given in terms of “speed,” including walking, which was indicative of much needed improvement, riding a bicycle, driving a car, riding a train, flying an airplane, or flying a rocket-ship, which was indicative of ultimate success. The final screen revealed a line graph, which showed their last several attempts at that particular game. In other words, the participants’ progress was charted in the program and stored from day to day. This encouraged players to work harder to improve their scores. Additionally, participants could assess their “Brain Age” once each day. This was done by completing a series of three randomly assigned activities. When playing the game, 20 is the lowest possible brain age, and therefore the ideal brain age. Working toward this goal provided additional
encouragement to work harder. Additionally, there was an integrated calendar that participants were prompted to “stamp” each day that they played. After completing one game they would get the stamp, and after completing three games that day the stamp would increase in size. This feature made it easy to identify the days that each participant actually played. From the NDSBA of each participant, the researcher retrieved the following data: the dates Brain Age was played, the number of days at least three games were played, how many times each individual game was played during the treatment period, and how many times they checked their “Brain Age” during the treatment period. This data was used to validate the information provided in the participant journals and interviews.

There are 10 different brain games that can be played using this software, 9 in the “Daily Training” section of the game, plus Sudoku. Participants were told that playing Sudoku would not count toward their 20 minutes of treatment time, only the 9 in the Daily Training section. Participants earned access to a new Daily Training game each day they played. Participants were told that once they had access to multiple games, they should rotate the games they played during their 20 minutes of treatment. This was to guide them into participating in a variety of brain activities, instead of picking a favorite and doing it repetitively. It was approximated that in order to reach the requested play time of twenty minutes, a participant who was actively involved would have to play a minimum of four games. If a participant was dragging out an activity, and did not have their mind on what they were doing, they could have possibly taken up 20 minutes with three games. In other words, if a participant averaged less than four games per day that they played, it was a fairly
accurate indicator that they either did not play for 20 minutes, or they were not playing with the concentration they should have been. A combination of computation, reading, and memory games were included in this software. A brief description of each game follows:

**Calculations X 20 - computation.** Twenty basic addition, subtraction, multiplication, and division problems appear one at a time, and players must write the correct answer. As with the remaining eight games, speed and accuracy are the keys.

**Calculations X 100 - computation.** This game is essentially the same as “Calculations X 20” except that there are 100 problems instead of 20. In both of the calculations games, players can choose to solve more difficult problems once they have proven a certain level of success with the easier problems.

**Reading aloud - reading.** A selection from a classic book is presented, and players must read the words aloud, and turn the pages by tapping “next,” until the game is finished. The game states that players may also choose to read to themselves. This game is solely based on the time it takes to read the selection, and is therefore reliant on the honesty of the player to read each and every word.

**Low to high - memory.** A small group of numbers, four on the first problem, is shown for a split-second. When the numbers disappear, empty boxes are left where they were. Players must tap the boxes in order of where the numbers were, from lowest to highest. When a player answers a problem correctly, the next problem will have an additional number to remember. When a player answers one incorrectly, the next problem will have one less number to remember.
**Syllable count - reading.** A sentence is shown. Players must write the number of syllables that are in the sentence.

**Head count – memory and computation.** A house is shown. People move in and out of the house for a few seconds. When the people are finished moving, the player must write the number of people that are left in the house.

**Triangle math - computation.** Three adjacent numbers, such as 5 8 1, are given. Players must calculate each adjacent pair of numbers such as 5 and 8, and 8 and 1, using whatever mathematical symbols are given below each pair. Then those two numbers must be calculated to get the final answer. For example, if all addition symbols were used in this problem, the process would look like: 5+8 = 13, 8+1 = 9...

13+9 = 22

**Time lapse - computation.** Two clocks are shown. Players must write how much time has elapsed between the two clocks in terms of hours and minutes.

**Voice calculation – computation.** Similar to “Calculations x20,” basic math problems are presented. Instead of writing the answer, players must say it aloud into the unit’s microphone.

**Data Analysis**

**Quantitative.** For analysis of the quantitative data, MATLAB (MathWorks, 2009) and SPSS (IBM, 2008) were utilized. The EEG data were exported from the BCI2000 software (Schalk et al., 2004) in ASCII format. A fast Fourier transform (FFT) was completed in MATLAB to establish pre-treatment, post-treatment, and follow-up theta and beta levels for each of the 12 activities completed by each
participant. Although this study was directed at evaluating activity in the prefrontal cortex, eye movements can cause artifacts in the output of frontally fixed electrodes (Leins et al., 2007). Since this study involved an open-eye EEG, the researcher followed the suggestion of Leins and associates, and utilized a more centrally located electrode. The Fz channel, which was at the center of the eight channels used in this study, was therefore utilized for analysis. Theta/beta ratios were computed in SPSS, and analyzed with a repeated measures ANOVA. A multivariate approach to repeated measures was used (Maxwell & Delaney, 2000), as well as a priori test of within-subjects contrasts, with Bonferroni corrected $\alpha = 0.025$.

Each participant also had pre-treatment and post-treatment FAB scores of 0-18. A paired samples t-Test was run to determine if there was a significant difference between the pre-treatment and post-treatment FAB scores across participants.

Because the statements of the SARAC are presented in both positive and negative formats, the scoring required an extra step. For the positive statements, representing behavioral and emotional engagement, responses were coded as follows: not at all true = 1, not very true = 2, sort of true = 3, very true = 4. For the negative statements, representing behavioral and emotional disaffection, responses were reverse coded as follows: not at all true = 4, not very true = 3, sort of true = 2, very true = 1. Each participant had pre-treatment, post-treatment, and follow-up SARAC scores of 20-80. A repeated measures ANOVA was run to determine if there was a significant difference between the three SARAC scores across participants.
Additionally, SARAC scores were broken down into two groups: engagement and disaffection, each with a possible score of 40. Those groups were then broken into four smaller groups: behavioral engagement, emotional engagement, behavioral disaffection, and emotional disaffection, each with a possible score of 20. When considering the disaffection scores, they actually represent “lack of” disaffection since reversed scoring was used for the negative statements. The additional breakdown of the SARAC scores allowed the researcher to see a better picture of how the participants related to their classrooms. Was their engagement, or lack of, more behavioral or emotional? Were the signs of engagement prominent, or did the participant just not show signs of disaffection? These questions were considered when writing the individual stories of participants. Although this information was interesting to the researcher, unless there is an explainable theoretical reason for contrasting the individual effects of the components, or studying particular combinations, it is more reasonable to utilize the combined scores for statistical analysis (Skinner et al., 2009). Since this study was not focused on comparing the individual components of engagement, no additional statistical analyses were run using this data.

Scoring of the TSARAC was completed in the same manner as the student SARAC. However, the TSARAC required an extra step for analysis. Eight of the participants had anywhere from one to three teachers submit the scales on their behalves. Because of this variance, it was decided to average each participant’s teacher scales for each collection point. Therefore each participant ended up with a pre-treatment, post-treatment, and follow-up TSARAC average from 20-80.
Additionally, as explained in Chapter 4, two of the participants did not have TSARAC scores. The imputation feature in SPSS was used to replace these missing values with the group mean for each administration of the TSARAC. A repeated measures ANOVA was run to determine if there was a significant difference between the pre-treatment, post-treatment, and follow up TSARAC averages across participants.

TSARAC scores were disaggregated and reported in the same manner as the student SARAC scores. However, the division of points varied in that behavioral and emotional engagement each had a possible score of 16, for a possible total engagement score of 32. Behavioral disaffection had a possible score of 16, while emotional disaffection had a possible score of 32, for a possible total disaffection score of 48. For this reason, along with the fact that combined TSARAC scores were a more practical choice for the needs of this study (Skinner et al., 2009), no additional analysis was completed using the TSARAC disaggregated data.

The five video questions and five reading questions (VQ/RQ) from each session were scored. This elicited a participant VQ/RQ total of 0 to 10 points for each session. A repeated measures ANOVA was run in SPSS to determine if there was a significant difference in pre-treatment, post-treatment, and follow-up VQ/RQ scores across participants. A post hoc pairwise comparison was also run since the ANOVA indicated significance (p < .05).

An alpha level of .05 was used to determine the significance of these t-Tests and ANOVAs. In addition to significance values and test statistics, effect sizes were calculated and reported for each statistically significant result. Cohen’s $d$ was calculated for the significant t-Test results, and partial eta squared ($\eta^2_p$) was
calculated for the significant ANOVA results. Table 4 illustrates the criteria for determining the strength of effect sizes (Huck, 2008).

Table 4

Effect Size Criteria for Comparing Two Means (adapted from Huck, 2008, p. 246)

<table>
<thead>
<tr>
<th>Effect Size Measure</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen’s $d$ ($d$)</td>
<td>.20</td>
<td>.50</td>
<td>.80</td>
</tr>
<tr>
<td>Partial eta squared ($\eta^2_p$)</td>
<td>.01</td>
<td>.06</td>
<td>.14</td>
</tr>
</tbody>
</table>

Qualitative. A variety of methods were used to analyze the qualitative data for this study. Since the engagement versus disaffection framework was being used, the primary analytical categories were already established. For this reason student journal entries were analyzed through deductive reasoning (Marshall & Rossman, 2006) by organizing them in a chart based on the journal prompts, and aggregating data regarding participants’ feelings and behaviors while at school, as well as factors affecting their engagement (see Appendix N).

Deductive analysis was used to analyze the data from participant post-treatment and follow-up interviews by organizing them in a chart separating data by session. A manual highlighting system was used to code information and find patterns regarding participants’ feelings and behaviors while at school, as well as factors affecting engagement. Direct interpretation was used to analyze any data that was outside of the categories stipulated by the engagement versus disaffection framework.
Inductive reasoning (Marshall & Rossman, 2006) and direct interpretation (Stake, 1995, p. 74) were used in the analysis of the parent pre-treatment, post-treatment, and follow-up questionnaires, as well as the researcher observations, and participant pre-treatment questionnaires. All of this data was aggregated in a chart separating information by data collection instrument and lab session (see Appendix O). This process is similar to that used in grounded theory (Strauss & Corbin, 1990).

Data collected from the participants’ Nintendo DS units were organized in a chart which illustrated the number of times participants played each game and the average number of games they played each day, among other details (see Appendix P). This data was used to confirm or refute the information provided in the participant journals and interviews.
Chapter 4: Findings

Organization of Chapter

The intent of this study was to determine if the daily use of brain games such as NDSBA could increase the engagement of students with ADHD. It was more specifically directed at finding a relationship between the participants’ use of brain games and their level of classroom engagement. This was achieved by studying the theta/beta ratios, self-reported engagement, teacher-reported engagement, researcher-reported engagement, parent-reported observance of ADHD symptoms, and executive functioning of 10 adolescents with ADHD. This chapter presents the results of the analysis of these data.

Descriptive statistics, including the mean and standard deviation for all three lab sessions, are reported for the five quantitative instruments. The presentation of the findings is organized by the six research questions. Table 5 specifies the research question each data collection instrument was used to answer.

Following the section focused on answering the research questions is a section dedicated to telling the individual stories of the 10 participants. A summary of the overall findings will follow the participant stories.

Descriptive Statistics

Table 6 reports the mean scores and standard deviations for the five quantitative instruments used during this study. Data are presented for all three sessions.
Table 5

*Data Collection Instruments by Research Question*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD?</td>
<td>EEG</td>
</tr>
<tr>
<td>2. What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD?</td>
<td>SARAC Participant journals</td>
</tr>
<tr>
<td>3. What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD?</td>
<td>TSARAC</td>
</tr>
<tr>
<td>4. What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?</td>
<td>Parent questionnaires</td>
</tr>
<tr>
<td>5. What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?</td>
<td>Researcher observations/checklist</td>
</tr>
<tr>
<td>6. What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?</td>
<td>FAB VQ/RQ</td>
</tr>
</tbody>
</table>

Table 6

*Mean Scores and Standard Deviations for Pre-treatment, Post-treatment, and Follow-up Sessions*

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Pre-treatment $n = 10$</th>
<th>Post-treatment $n = 10$</th>
<th>Follow-up $n = 10$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>SARAC</td>
<td>53.50</td>
<td>9.372</td>
<td>56.90</td>
</tr>
<tr>
<td>T-SARAC</td>
<td>51.30</td>
<td>7.558</td>
<td>53.00</td>
</tr>
<tr>
<td>FAB</td>
<td>14.80</td>
<td>2.936</td>
<td>16.40</td>
</tr>
<tr>
<td>Theta/Beta*</td>
<td>7.829</td>
<td>1.511</td>
<td>5.754</td>
</tr>
<tr>
<td>VQ/RQ</td>
<td>10.70</td>
<td>2.003</td>
<td>14.40</td>
</tr>
</tbody>
</table>

*Note.* *Theta/beta ratio is calculated by dividing the power of the theta band by the power of the beta band.*
Results by Research Question

Research question one: What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD?

EEG. To answer research question one, EEG assessments were completed during all lab sessions. During each of the 3 EEG sessions, participants completed four tasks, for a total of 12 tasks per participant. The EEG data were exported from BCI2000 (Schalk et al., 2004) in ASCII format. A fast Fourier transform (FFT) was completed in MATLAB (MathWorks, 2009) to establish pre-treatment, post-treatment, and follow-up theta and beta levels for each of the 12 tasks completed by each participant. Output from channel Fz, which is approximately located over the center of the frontal lobe, was utilized for analysis. Theta/beta ratios were computed in SPSS (IBM, 2008), and analyzed by session and task with a repeated measures ANOVA. A multivariate approach to repeated measures was used (Maxwell & Delaney, 2000), as well as a priori test of within-subjects contrasts, with Bonferroni corrected $\alpha = 0.025$.

The effect of session on mean theta/beta ratio was significant ($F[2,8] = 5.275; p = .035; \eta^2_p = .569$), which, in this case, meant that there was a significant difference between theta/beta ratios for the post-treatment and follow-up sessions. This suggests a large relationship between session and mean theta/beta ratio. Although there was actually a greater difference in the means of the pre-treatment and post-treatment ratios, it was not significant. However, in a test of within subject contrasts, the mean of the pre-treatment and follow-up ratios, contrasted with the post-treatment ratio, was significant, and had a large effect size ($F[1,9] = 11.432; p =$
.008; $\eta^2_p = .560$). Figure 6 illustrates the relationship between session and theta/beta ratio.

![Main Effect of Session](image)

Figure 6. Main effect of session on theta/beta ratios.

Task did not have a significant effect on mean theta/beta ratio ($F[3,7] = .660$, $p = .602$). This means that there was no significant difference in theta/beta ratios between the four tasks. The activity choice of watching a video, versus reading, did not affect the theta/beta ratios, nor did the presence of the researcher-presented distractions. There was a significant interaction between session and task ($F[6,4] = 10.405$, $p = .020$), meaning that the session had an effect on the ratio of each task. As can be seen in Figure 7, the ratios for all four activities followed the same pattern, down at post-treatment and back up at the follow-up, but to different degrees. The effect size for this relationship was large ($\eta^2_p = .940$).
**Research question two: What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD?**

*SARAC.* To answer research question two, the Student’s Achievement-Relevant Actions in the Classroom (SARAC), a student self-report of engagement versus disaffection (Skinner et al., 2009) was utilized. SARAC items have a four-point scale: not at all true, not very true, sort of true, very true (see Appendix A). Participants completed the SARAC at each of the three lab sessions. Each document was tallied by the researcher, and given a score out of a possible 80 points. A repeated measures ANOVA showed that there was not a significant effect of session on SARAC scores ($F[2,18] = .932, p = .412$). This means that although SARAC scores increased from pre-treatment to post-treatment, and decreased from post-

---

*Figure 7.* Mean theta/beta ratio by task and session.

![Interaction of Session and Task](image-url)
treatment to follow-up, the difference was not significant. Figure 8 shows the mean SARAC scores by session.

![SARAC Means by Session](chart)

**Figure 8.** Mean SARAC scores by session.

**Participant journals.** To support the SARAC data in answering research question two, participants kept a daily electronic journal for the duration of the study. Journal prompts were designed based on Skinner and Belmont’s engagement versus disaffection framework (Skinner et al., 2009) (see Appendix D), to ensure that journal entries provided information regarding the participants’ focus at school that was consistent with the study’s theoretical framework. Journal entries were analyzed through deductive reasoning (Marshall & Rossman, 2006) by organizing them in a chart based on the journal prompts, and aggregating data regarding participants’ feelings and behaviors while at school, as well as factors affecting their
engagement (see Appendix N). One participant, Hayden, did not complete a journal, so there were only nine journals to utilize in this process.

Out of the nine participant journals that were completed, six of them showed some sort of pattern or evidence of increased engagement from the pre-treatment to the post-treatment period. John’s journal indicated less boredom beginning with the second week of treatment, and alternating days of disaffection returning during the follow-up period. On the fourth day of treatment, Aaron began expressing more positive feelings that continued through the rest of the treatment period. His follow-up entries indicated more consistent feelings of boredom. For Caleb, his overall engagement during the treatment period seemed to be better, with him only reporting negative feelings or behaviors on 13% of the days. During the follow-up period, he reported some sort of disaffection on 44% of the days. Eli only reported being sleepy or bored on four days during the treatment period, but reported boredom on both of the follow-up entries he wrote. During the treatment period, Fynn included at least one positive comment in his entries 56% of the time. However, during the follow-up period, he only made one or more positive comments in 20% of the entries. Lastly, Galen’s only negative statement during the treatment period was on the first day, while 2 of his 10 entries during the follow-up period suggested disaffection. These results are summarized in Table 7. Specific quotes are provided in the individual participant stories.

Because of the different lengths and styles of entries, it was difficult to narrow the results to only one kind of pattern. However, the journals of these six
participants all show better engagement during the treatment period than during the follow-up period.

Table 7

Summary of Journal Entries

<table>
<thead>
<tr>
<th></th>
<th>Treatment Period</th>
<th>Follow-up Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>No trend</td>
<td></td>
</tr>
<tr>
<td>John</td>
<td>starting the middle of the 2nd week, less boredom</td>
<td>alternating days of boredom</td>
</tr>
<tr>
<td>Aaron</td>
<td>starting the 4th day, more positive feelings</td>
<td>boredom became more consistent</td>
</tr>
<tr>
<td>Blake</td>
<td>No trend</td>
<td></td>
</tr>
<tr>
<td>Caleb</td>
<td>reported negative feelings or behaviors on 13% of the days</td>
<td>reported negative feelings or behaviors on 44% of the days</td>
</tr>
<tr>
<td>Dante</td>
<td>No trend</td>
<td></td>
</tr>
<tr>
<td>Eli</td>
<td>1st day - reported distraction, bored on 1 other day</td>
<td>only wrote 2 entries during these 2 weeks, both reported boredom</td>
</tr>
<tr>
<td>Fynn</td>
<td>56% of the days included at least 1 positive comment</td>
<td>only 20% of the days included at least 1 positive comment</td>
</tr>
<tr>
<td>Galen</td>
<td>negative statement only on 1st day</td>
<td>negative statement on 2 of the 10 days</td>
</tr>
<tr>
<td>Hayden</td>
<td>No journal</td>
<td></td>
</tr>
</tbody>
</table>

**Participant post-treatment and follow-up interviews.** The final data used to help answer research question two were participant post-treatment and follow-up interview transcripts. The questions in the post-treatment interview were open-ended and were directed at gathering details about the five weeks of treatment (see Appendix F). Participants were asked to identify any difference they had noticed in their ability to focus at school or engage in class during the treatment period.

The questions used in the follow-up interview (see Appendix G) were open-ended and were directed at gathering details about the three post-treatment weeks (Spring Break, followed by two weeks of school). Participants were also asked to
give their opinion regarding the use of brain games as treatment for symptoms of ADHD.

Participant post-treatment and follow-up interviews were organized in a chart separating data by session, and a highlighting system was used to code information and find patterns regarding participants’ feelings and behaviors while at school, as well as factors affecting engagement. During the post-treatment interviews, seven participants stated that they had noticed a positive difference in their ability to focus, pay attention, concentrate, or engage in class. Three of the participants indicated that they felt more awake during the treatment period, and two more indicated that their classroom behavior had improved. Additionally, four participants shared that they felt they were specifically doing better in math class. Only one participant reported that he did not notice any difference during the treatment period. No participants reported a decreased ability to focus.

During the follow-up interviews, seven participants indicated that, since they had stopped playing the games, they were less focused and having a harder time paying attention in class. The follow-up interviews also revealed that two participants were less awake, one had worse classroom behavior, two were more fidgety, one was bored in class, and one participant’s grades had dropped since the treatment had ceased. Interestingly, four participants also shared that they felt they were getting angrier faster and more easily since stopping the games. The same participant that stated he did not notice any differences during the treatment period also stated that he could not tell a difference after stopping the games.
Research question three: What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD?

**TSARAC.** The TSARAC, comprised of 20 statements, and scored from 20 to 80, was completed by the participants’ teachers for each phase of the study. A repeated measures ANOVA showed that there was not a significant effect of session on TSARAC scores ($F[2,18] = .965, p = .40$). This means that, although TSARAC scores increased from pre-treatment to post-treatment, and decreased from post-treatment to follow-up, these changes were not significant.

![Mean TSARAC Scores by Session](chart)

*Figure 9.* Mean TSARAC scores by session.

Research question four: What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?

**Parent post-treatment and follow-up questionnaires.** The data from parent questionnaires were used to answer research question four. Data were organized in
a chart by session (see Table 8). A highlighting system was used to code information and find patterns regarding the parents’ observances of the participants’ symptoms of ADHD.

Table 8

Summary of Parent Questionnaires

<table>
<thead>
<tr>
<th>Name</th>
<th>Post-treatment</th>
<th>Follow-up</th>
<th>Did the games make a difference?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>didn’t notice change in Bx/attitude; did a little better in school</td>
<td>attitude not good; no difference in school performance; games better than meds</td>
<td>yes</td>
</tr>
<tr>
<td>John</td>
<td>did not notice change in Bx/attitude or school; study might have been too short</td>
<td>did not notice change</td>
<td>not sure</td>
</tr>
<tr>
<td>Aaron</td>
<td>grades went up (didn’t notice or report until follow-up)</td>
<td>immediate minor change in Bx/attitude; more difficult to wake up</td>
<td>yes</td>
</tr>
<tr>
<td>Blake</td>
<td>much calmer, less defiant, less agitated, more on task (noticed 2nd week of treatment)</td>
<td>1-2 days after stopping treatment, immediately became more agitated, easily irritated, unfocused, and antagonistic</td>
<td>yes</td>
</tr>
<tr>
<td>Caleb</td>
<td>didn’t really notice change in Bx/attitude; a lot more calm after 3 weeks (treatment or other?)</td>
<td>felt he went to school in a more prepared mind-set; calmer demeanor and confidence</td>
<td>yes</td>
</tr>
<tr>
<td>Dante</td>
<td>Bx/attitude would improve then get worse for a couple weeks; last 2 weeks consistently good; week 5 was best ever in school</td>
<td>sustained improvements since he stopped playing; better at home and school</td>
<td>not sure - he wasn’t playing as instructed</td>
</tr>
<tr>
<td>Eli</td>
<td>didn’t really seen any improvement; still impulsive and scatter-brained; helped a bit with focus and memory (didn’t report until follow-up)</td>
<td>no change in Bx or attitude; difference in school performance (no elaboration)</td>
<td>yes</td>
</tr>
<tr>
<td>Fynn</td>
<td>seemed more confident, liked the routine, he told her the games were helping him stay focused</td>
<td>didn’t seem as studious or organized; noticed after spring break; grades stopped going up; seemed to have lost his drive</td>
<td>yes</td>
</tr>
<tr>
<td>Galen</td>
<td>after 3 wks he started doing better in school, grades increased by a letter in 3 subjects</td>
<td>decrease in his organization and school performance; drop in grades; after spring break</td>
<td>yes</td>
</tr>
<tr>
<td>Hayden</td>
<td>noticed change in school performance after about a week; grades up to A’s and B’s</td>
<td>less focused, declining grades; noticed a couple days after school started back</td>
<td>yes</td>
</tr>
</tbody>
</table>

Note: “Bx” is an abbreviation for behavior, commonly used in the medical profession.
On the post-treatment questionnaires, 7 out of 10 parents reported that their child was doing better in school, or more specifically, had increased their grades since the start of the treatment period. Three parents specified that their child seemed to be more focused or on task. Two parents indicated that their child’s behavior had improved, and another stated that her son seemed more confident, and liked the routine of playing the games. Additionally, two parents noted that their child seemed calmer since starting treatment. However, one of these claims was not made until the follow-up session. Only one parent stated that she did not notice any change in her child’s symptoms of ADHD. This was not, however, the parent of the participant who indicated that he had not seen any change.

On the follow-up questionnaires, four parents reported a decrease in their child’s school performance, or more specifically a drop in grades, since the treatment period had ended. Three parents indicated that their child’s behavior had gotten worse, and two others stated that their child’s organization was not as good. Two reported that their child seemed less focused. Additionally, one parent indicated that her son had been more easily agitated or irritated since stopping the treatment.

**Research question five: What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?**

**Researcher observations.** To answer research question five, during all three lab sessions, the researcher recorded any observance of the indicators of engagement and disaffection using Table 1 as a checklist. General field notes were also recorded during each session.
Checklists results were analyzed using a chart that separated characteristics of disaffection from characteristics of engagement, for each of the three sessions (see Table 9). Signs of disaffection were coded as negatives, and signs of engagement were coded as positives. The overall result of increased engagement, decreased disaffection, or a combination of both was considered a positive change. If the overall result was that of decreased engagement, increased disaffection, or a combination of both, this was considered to be a negative change.

Table 9

Reconseacher Observation Checklist Data

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>John</td>
<td>6</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Aaron</td>
<td>0</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>Blake</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Caleb</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dante</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Eli</td>
<td>0</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>Fynn</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Galen</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hayden</td>
<td>0</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

Note. “Δ” represents the change in engagement between the two sessions on either side of the Δ column. Negative Δ numbers represent an overall decrease in engagement, increase in disaffection, or both. The opposite is true for positive Δ numbers.
From pre-treatment to post-treatment, the researcher observed a large positive change for four of the participants (≥3), and a smaller positive change for three of the participants (1-2). For two participants, no change was reported, while one participant actually demonstrated a small negative change (-1). Overall, from pre-treatment to post-treatment, there were half as many indicators of disaffection, while there were half again as many indicators of engagement. During the follow-up sessions, many indicators of engagement were still present. However, for some of the participants, the indicators of disaffection had increased.

**Research question six: What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?**

*FAB.* To answer research question six, a frontal assessment battery (FAB) (Dubois et al., 2000) was administered to participants at the pre-treatment and post-treatment sessions. Table 10 provides the means and standard deviations for each of the six prompts on the FAB. Zero to three points were awarded for each

Table 10

*Mean Scores and Standard Deviations for FAB Prompts*

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptualization</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Mental flexibility</td>
<td>2.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Programming</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Sensitivity to interference</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Inhibitory control</td>
<td>2.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Environmental autonomy</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
prompt based on the number of errors in the participant’s response (See Appendix C). If a participant did exactly what the researcher asked for a particular prompt, 3 points were awarded, for a possible total of 18 points. A paired sample t-Test revealed that there was a significant difference between the pre-treatment FAB ($M = 14.80, SD = 2.936$) and post-treatment FAB ($M = 16.40, SD = 2.011$), ($t[9] = 2.516, p = .033$), with a medium to large effect size ($d = .67$).

**VQ/RQ.** The video and reading questions (VQ/RQ) that were completed during each EEG session were also used to help answer research question six (see Appendixes K and L). There were five prompts following each of four cognitive tasks. Answers were tallied, and participants were given scores out of a possible 20 for each session. Figure 10 shows the Mean VQ/RQ scores by session.

![Mean VQ/RQ Scores by Session](image)

*Figure 10. Mean VQ/RQ scores by session.*
The follow-up VQ/RQ mean ($M = 14.70, SD = 2.214$) was higher than both the pre-treatment mean ($M = 10.70, SD = 2.003$) and post-treatment mean ($M = 14.4, SD = 3.340$). A repeated measures ANOVA showed a significant effect of session on VQ/RQ ($F[2, 18] = 8.12, p = .003$), with a large effect size ($\eta^2_p = .474$). In other words, there was a significant difference between the VQ/RQ means for two or more sessions. A pairwise comparison with Bonferroni correction showed that, although the post-treatment mean was 3.7 points higher than the pre-treatment mean, significance ($p = .02$) was not achieved until the follow-up session when the mean was 4.0 points higher than the pre-treatment mean.

**Participant Stories**

“Jane.” This participant was a Caucasian, 16 year-old female, who attended a public high school. Jane's maternal grandmother, with who she has lived most of her life, stated on the parent pre-treatment questionnaire that she started noticing some of the signs of ADHD when Jane was nine years old and in the fourth grade. Jane was tested, and diagnosed as having primarily inattentive type ADHD at that time. Unfortunately, her grandmother was not very thorough or specific in her completion of the parent pre-treatment questionnaire, and this was all of the information that she provided regarding Jane’s early history with ADHD, except for stating that she had “tried medication”.

Through her responses on the participant pre-session questionnaire, Jane revealed the following information. She had previously been prescribed, and had taken, medication for ADHD. However, at the time of the study, by her own choice, she had not been taking the medication, and said that she would not be taking it
during the course of the study. She typically played video games once a week for two hours, and preferred action type games. Caffeine was not a part of her regular diet, and she had never been a smoker. She had never suffered from any short or long-term memory or speech loss due to a concussion or blow to the head. Neither relaxation nor meditation were a part of her daily routine. She considered herself to be highly active, adding that she rode horses with her friends.

**SARAC.** On the pre-treatment SARAC, Jane scored a total of 46/80. Based on her responses, she did not listen in class, and tended to think about other things. Jane indicated that she liked to learn new things in class, but pretty much just exerted enough effort to get by.

On the post-treatment SARAC, she scored 58/80, which was 12 points higher than she scored on the pre-treatment administration. Her responses indicated that during the treatment period, she was trying harder in school, but that she still thought about other things during her classes.

Her follow-up SARAC score was 43/80, which was 15 points lower than on the post-treatment SARAC, and very close to her pre-treatment score. Similar to the pre-treatment SARAC, her responses indicated that she was not trying very hard in school, and pretty much doing just enough to get by. Her responses also implied that school is not at all fun for her.

Based on the disaggregation of Jane's SARAC scores, shown in Table 11, her engagement level in class tends to be affected more by her behaviors than emotions, and influenced by the presence of negative indicators (disaffection) rather than the absence of positive ones (engagement) (see Table 1).
Table 11

Disaggregation of Jane’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>11</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>14</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>25</td>
<td>30</td>
<td>23</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Only one teacher submitted the TSARAC for Jane. Jane explained that this was because her math teacher is the only one she liked enough to ask her to complete it. That teacher’s responses to the TSARAC resulted in a total of 43/80, which was only slightly below the total on Jane’s self-report. Based on the teacher’s responses, Jane acted uninterested in class, and did not work very hard.

The responses on her math teacher’s post-treatment TSARAC totaled 44/80, which was just 1 point higher than on the pre-treatment administration. Her responses indicated that from her perspective, Jane still did not seem interested or work very hard in class.

On the follow-up TSARAC, she received a total of 42/80, which was within two points of both the pre-treatment and post-treatment administrations. Her responses to individual items on the questionnaire were very similar to her responses the first two times, indicating that, from her perspective, Jane was still not working hard in class or showing interest.

Table 12 shows the disaggregation of Jane’s pre-treatment, post-treatment, and follow-up TSARAC scores. However, as explained in the section on data analysis,
because the points on the teacher version vary between emotional disaffection and the other three factors of engagement, no additional analyses were conducted.

Table 12

Disaggregation of Jane’s Pre-treatment, Post-treatment, and 3-Week Follow-up TSARAC Scores

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Pre</th>
<th>Post</th>
<th>3-w</th>
<th>Pre</th>
<th>Post</th>
<th>3-w</th>
<th>Total (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral (16)</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>20</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>13</td>
<td>10</td>
<td>9</td>
<td>30</td>
<td>34</td>
<td>33</td>
<td>43</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**FAB.** Jane scored 16/18 on the pre-treatment FAB. She appeared to be very relaxed and focused during the administration. One point was deducted from prompt #1 (see Appendix C) because she responded that a table and chair were alike since they were used in dining, rather than responding that they were both furniture. One point was deducted from prompt #3 as well. On the post-treatment FAB, Jane scored 18/18. She appeared to be even more relaxed and focused than during the pre-treatment administration.

**EEG and video/reading questions.** As can be seen in Table 13, from pre-treatment to post-treatment, there was a decrease in Jane’s theta/beta ratio for all four activities. For both reading activities during the follow-up session, theta/beta ratios were lower than during the post-treatment session. However, ratios for both video activities were higher than during the post-treatment session.

During the pre-treatment EEG session, Jane only scored 12/20 on the VQ/RQ. However, on the post-treatment administration, her total increased to 18/20. She scored one point lower on the follow-up, for a total of 17/20.
Table 13

Jane’s Theta/Beta Ratios

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>8.60</td>
<td>7.08</td>
<td>6.07</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>11.36</td>
<td>6.84</td>
<td>5.48</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>10.41</td>
<td>6.04</td>
<td>6.63</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>9.39</td>
<td>6.19</td>
<td>10.41</td>
</tr>
<tr>
<td>Mean</td>
<td>9.94</td>
<td>6.54</td>
<td>7.15</td>
</tr>
</tbody>
</table>

Jane’s scores over time. Figure 11 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. As illustrated by Figure 11, Jane

![Figure 11](image-url)
showed improvement from pre-treatment to post-treatment on all of the instruments, although the improvement on the TSARAC was slight. Additionally, she showed a regression from post-treatment to follow-up on all of the instruments. Keep in mind, when viewing the participant percentage of change charts, that the researcher predicted a negative correlation between the theta/beta ratios and the other four quantitative instruments, and that a decrease in ratio is considered to be an improvement.

**Participant journal and NDSBA.** Jane’s journal entries spanned a four-week period from February 28 through March 24, with no entries being recorded for the last week of treatment, nor the two weeks without treatment. On nine days she reported that she played 20 minutes, on seven days “about 20 minutes”, and one day she stated that she did not play because she was running late. Based on the data retrieved from the NDSBA, she played the brain games on 15 of the 25 assigned treatment days. However, the days that the NDSAB indicated she played did not match up with the dates of her journal entries. It appeared by the modification dates of her journal files that she might have written two or three days of entries at one sitting. Perhaps she just misdated the journal entries, but the fact that they were not written on a daily basis, and did not coincide with the dates within the game system, compromises their trustworthiness. Furthermore, it was calculated that a participant would have to complete approximately four brain games to reach the minimum play time of 20 minutes. Since she averaged 1.6 games per day that she played, it is highly unlikely that she played for 20 minutes each time, as she
reported. As far as the variety of games that she played, four of the nine she did not play at all, and the other five were played one to eight times each.

Aside from the fact that her journal entries were not very trustworthy, there was no observable trend found within the entries. She repeatedly stated throughout her entries that she did not like her 4th period teacher, and even once specified, “I like getting an attitude with my 4th period teacher.” Her feelings about school at the beginning of the treatment period were similar to those at the end. She considered herself focused on most days, with a few entries stating that she was bored, or had slept in class. In other entries she referred to her behavior in her classes as “chill.”

**Participant interviews.** During her post-treatment interview, Jane explained that, during the five weeks of treatment, she left her NDSBA out on her desk so she would remember to play it each morning. She stated that she played away from distraction, and put a good amount of effort into the activities. Some of the games she enjoyed playing, but others she did not like as much. She indicated that she had seen some improvement in her engagement during the five weeks of treatment. Specifically, she said that she was doing better in math, completing her work, and finding it easier to concentrate. Additionally, she believed the math practice games were helping her in math class, because she was getting faster at recalling basic facts. On a side note, Jane disclosed that she had been assigned to in-school suspension quite a bit during the treatment period, because she was late getting to her classes due to campus construction. When asked how she thought the following couple of weeks would be, since she would not be playing the game each morning, she predicted that she might end up sleeping more in class.
During the follow-up interview, Jane indicated that she had not played any sort of brain games during the three weeks since ceasing treatment. She claimed that she could tell a change in her ability to focus and engage in class since stopping the games, explaining that she was sleeping more and having a more difficult time paying attention. She also expressed that she got angry at things faster after she stopped playing the games. Things that did not bother her while she was playing the games were making her mad again, and she also felt more calm at home and school when she did play the games. She said she noticed this difference about two or three days after returning from spring break. In her opinion, the games made a difference. She stated that she intended to resume the use of the games on school days for 10-15 minutes per day, or possibly 20 minutes.

**Parent observations.** On the parent post-treatment questionnaire, Jane’s grandmother, who had raised her, left several questions blank, and was very brief with the answers she did provide. She stated that she did not notice any change in Jane’s behavior, attitude, or school performance, but then wrote, “I believe she did a little better in school.” She said that Jane did not turn projects in when they were assigned. She added that she thought Jane enjoyed playing the games.

As with the first two parent questionnaires, the responses on the parent follow-up questionnaire were very brief. Jane’s grandmother stated that Jane’s attitude was not good after she stopped playing the games. She said she did not really notice any difference in school performance, but she still thought he use of brain games was better than medication. She indicated that she intended for Jane to resume playing the brain games before school each morning.


**Researcher observations.** During the pre-treatment session, Jane presented as a shy teenage girl, who tried to be a little edgy, as opposed to preppy. When she arrived, she was wearing a hooded sweatshirt, torn jeans, and cowboy boots, and was listening to her iPod, until her mother asked her to remove the earbuds and turn it off. It was her birthday, and she was very quiet at first, appearing as if she would rather be somewhere else. When given the assent form to sign, she did not want to take the time to read it. She just wanted her mother and the researcher to summarize what it said. Having taught Jane in the 6th grade, the researcher asked her how school was going. She stated that it was “good.” The researcher also asked how her grades were, and she responded that they were “okay.” When asked to clarify that response, she explained that she did not do her homework. As the session progressed, she appeared more comfortable being there. The boredom, disinterest, and passivity she showed during the session were signs that she was feeling more disaffected than engaged. Concentration on the activities was the only observable sign of engagement.

During the post-treatment session, Jane displayed interest, pride, effort, and concentration, which are all signs of engagement, and did not display any signs of disaffection.

During the follow-up session, Jane was very interested in the results of the study thus far, and kept asking the researcher questions about it. As in her post-treatment session, she displayed many signs of engagement, including concentration, involvement, interest, and vitality. There were no signs of disaffection. A discussion of Jane’s story can be found in Chapter Five.
“John.” This participant was an Asian, 12 year-old male, who attended a public middle school. His adoptive mother, who is Caucasian, stated on the parent pre-treatment questionnaire that John was six when she started noticing that he was having handwriting problems, memory problems, difficulty focusing, and was giving up easily on tasks. Two years later, upon teacher recommendation, she talked to his pediatrician about the symptoms she had noticed and the difficulty he was having at school. At the age of 10, he was diagnosed with combined type ADHD. John took the prescription stimulant Vyvanse for six months, but his schoolwork did not improve, and he was having trouble sleeping at night, so they discontinued the use of it. His mother stated that his symptoms seemed to get “stronger” every year. She shared that she was concerned about his ability to learn more difficult concepts and sustain interest long enough to benefit from his lessons. She stated that she hoped being involved in this study would help him “tap into his ability to focus,” and give them insight to what future alternatives to medication might help reduce his symptoms of ADHD.

His responses on the participant pre-session questionnaire revealed the following information. At the time of the study, John was not taking any medication for ADHD. He stated that he played video games every day for about an hour, and liked all different genres of games. He indicated that he did not consume caffeine on a regular basis, nor was he a smoker. John indicated that he had suffered from short or long-term memory or speech loss due to a concussion or blow to the head. He said to ask his mother for details. She clarified that he had received a few blows to his head. In the fourth grade, he fell off the monkey bars and sustained a head injury
that required stitches, and she believed the trauma caused the incident to remain at the forefront of his memory. He had not, however, suffered from any memory loss due to those incidents, and was never knocked unconscious. Nevertheless, further research of this participant could reveal that his previous head trauma had influenced the severity of his ADHD symptoms. Finally, John stated that he did not participate in any sort of meditation or relaxation on a regular basis, and considered himself to be moderately active.

**SARAC.** On the pre-treatment SARAC, John scored 45/80. His responses indicated that he did not enjoy school, and his mind tended to wander, but that he put forth a little effort. In some ways, his responses were conflicting. For instance, he responded “sort of true” that he did just enough to get by in class, but then answered “very true” that he worked as hard as he could in class. Another example is that he answered “sort of true” that he listened very carefully in class, but “not very true” that he paid attention in class. These conflicting answers could mean that he was confused by the wording of some prompts, or possibly that he did not put a lot of thought into his responses.

John’s score on the post-treatment SARAC was 41/80, which was 4 points lower than he scored on the pre-treatment administration. His responses were very similar to those on the first SARAC, including the conflicting responses regarding the amount of effort he put into his class work. This suggested that he most likely had read the prompts, but had a little difficulty with the meaning of some of them.

His follow-up SARAC score was 50/80, the highest of all three administrations. The biggest difference was in the emotional disaffection category.
He reported not feeling as bored or discouraged as he reported the first two times.

He also indicated that class was a little more fun for him at that point in time.

As seen in Table 14, his overall level of engagement increased during the follow-up period, as he reported feeling less emotionally disaffected, and slightly more behaviorally engaged.

Table 14

*Disaggregation of John’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores*

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>15</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>9</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>24</td>
<td>22</td>
<td>25</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** John’s social studies, science, and math teachers submitted completed TSARAC forms on his behalf. The average of the pre-treatment TSARAC scores was 44/80. There was a general consensus that John was not that interested in class, and did not pay close attention. They all agreed that he never did more than was required of him, thought about other things, seemed restless, came unprepared, and seemed unhappy.

The average of his teachers’ responses on the post-treatment TSARAC was 44/80, exactly the same as on the first administration. His teachers were still in agreement that he was not that interested in class, did not pay close attention, never did more than was required of him, thought about other things, seemed restless, came unprepared, and seemed unhappy. However, his math teacher indicated a
much higher level of emotional disaffection than his other teachers. This would make sense considering John wrote in his journal, “Math class is always boring,” but never made negative comments specifically about his other classes.

On the follow-up TSARAC, the average score was 43/80, which was one point lower than the two previous administrations. Responses were very similar to the first two. In fact, the math teacher had the same responses, and wrote in the same pen color as on the second form. It is possible that she actually filled them both out at the same time, weakening the trustworthiness of her responses.

Table 15 shows the disaggregation of John's TSARAC scores, illustrating that not only were the total scores very close between administrations, but also the scores for the individual components.

Table 15

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre  Post 3-w</td>
<td>Pre  Post 3-w</td>
<td>Pre  Post 3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>7        6   6</td>
<td>7        9   9</td>
<td></td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>9        8   8</td>
<td>21        21  20</td>
<td></td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>16   14  14</td>
<td>28        30  29</td>
<td>44        44  43</td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of point possible for that sub-category.

**FAB.** John scored 15/18 on the pre-treatment FAB. During the administration, he was very fidgety. One point was deducted from prompt #1 because he responded that a table and chair were alike since they were found in the living room, rather than responding that they were both furniture. One point was also deducted from prompt #3 and prompt #4.
John scored 17/18 on the post-treatment FAB, which was 2 points higher than on the pre-treatment administration. One point was deducted from prompt #1, as on the first administration, because he responded that a table and chair were alike since they were both found in the kitchen, rather than responding that they were furniture. This was a different room than he stated the first time, but still not the category in which they belonged. It was surprising to the researcher that he did as well as he did, considering his level of distractibility during the session.

**EEG and video/reading questions.** Table 16 illustrates that John’s theta/beta ratios went up for all four activities between the pre-treatment and post-treatment EEG sessions. His ratios for three of the activities went up again between the post-treatment and follow-up sessions.

John only scored 8/20 on the VQ/RQ during the pre-treatment EEG session. On the post-treatment administration, his total increased to 17/20. During the follow-up session, his score decreased 2 points to 15/20.

Table 16

*John’s Theta/Beta Ratios*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>2.88</td>
<td>5.69</td>
<td>8.28</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>5.38</td>
<td>6.76</td>
<td>8.59</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>4.12</td>
<td>4.64</td>
<td>6.62</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>4.06</td>
<td>4.87</td>
<td>4.61</td>
</tr>
<tr>
<td>Mean</td>
<td>4.11</td>
<td>5.49</td>
<td>7.03</td>
</tr>
</tbody>
</table>

*John’s scores over time.* Figure 12 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in
mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Note that John's VQ/RQ and FAB scores were the only ones that improved from pre-test to post-test. There does not appear to be any noteworthy pattern from post-treatment to follow-up.

![Graph](image)

*Figure 12.* John's percentage of change on the quantitative instruments across sessions.

**Participant journal and NDSBA.** John completed 23 journal entries from February 28 to April 1, and 5 entries from April 11 to 15, but did not write any entries for the second post-treatment week. On each of the 23 days during the treatment period, he reported that he played anywhere from 20 to 36 minutes. The first week of treatment, his entries included some interesting details. For instance, on day one, in response to journal prompt #5 (see Appendix D), he shared that he
was concerned because most of his friends had girlfriends and he was a “bachelor.” On day three, in response to journal prompt #3a, he stated, “I did my best but, teachers looked at me, and their look said, ‘MAN THAT KID IS SHOWING NO EFFORT’." As the study moved forward, his entries contained less detail, but he always included a somewhat descriptive word in response to prompts #2a and #3a, and included information in response to prompt #4. A pattern did emerge in regard to John’s emotional and behavioral engagement at school. Through the first week and a half of treatment, he generally reported feeling “bored” or “annoyed,” with a primary tone of disaffection. From the middle of the second week of treatment, until the end of treatment, he consistently reported feeling “interested,” “good,” or “awesome” about school, with an overriding tone of engagement. During those last three and a half weeks of treatment, he only reported being bored on two of the days on which he had played the brain games. On the one day that he reported not playing the games, he stated that his feelings about school that day were “horrible,” his behavior was bad, and he fell asleep in his classes. During the post-treatment period, he tended to have alternating days of engagement and disaffection.

Data retrieved from John’s NDSBA strengthened the trustworthiness of his journal entries. With an average of 4.4 games played per day, it is highly likely that he did indeed play for at least 20 minutes each morning. He played a reasonable variety of games. However, he did not play three of the games at all.

**Participant interviews.** During the post-treatment interview, John explained how he would have remembered to play his game and write in his journal on his own, but his father reminded him anyway. He said that he put a good amount of
effort into the brain games and enjoyed playing them. He felt that during the five weeks of treatment, he was more focused in class. He also mentioned that he did not fall asleep in class as much. He said that during the following weeks, since he would not be playing the brain games each day, he expected to be a little less focused in class. He was proud to share that he had gotten down to a brain age of 26.

John indicated in his follow-up interview that he did not play any sort of brain games during the three weeks since stopping treatment. He said that he felt a difference at school because he was so used to playing the games, it just “didn’t feel right.” He explained that he was moving about more, tapping a lot, and his grades were lower than during the treatment period. He stated that he noticed the change when school started back after spring break. He believed the brain games did make a difference in his ability to focus, engage in class, and manage his ADHD symptoms. He said he intended to resume the use of brain games, but wanted his mother to buy him a different game to play. He said he would play on school mornings, but only when he was in an “interested mood.”

**Parent questionnaires.** On the parent post-treatment questionnaire, his mother indicated that she did not really notice any change in John’s behavior, attitude, or school performance from the beginning to the end of the treatment period. However, she said she believed this line of treatment could be beneficial to John, but that the study might have been too short. At the time of the post-treatment session, she had not yet decided if they would resume the use of the brain games when the study was over.
John’s mother indicated on the parent follow-up questionnaire that she did not really notice any change in his behavior, attitude, or school performance since stopping the brain games. She said she had not decided what she thinks about the use of brain games for treating ADHD, and would try them again. She stated, “I think I should have spoken more in-depth with his teachers about the study. I was disappointed with their response time on the surveys.”

**Researcher observations.** John was brought to each of the lab sessions by his mother. During the pre-treatment session, John presented as a talkative and friendly, but immature, child. Throughout the session, he was very wiggly, rocking in his chair, clicking his pen, lying across the table, and generally active. His choice of conversational topics was somewhat abnormal for a child his age. For instance, he asked if the EEG could detect lies, and then proceeded to pretend he was answering questions in a lie detector session. “What kind of underwear are you wearing?” he asked, not of the researcher, but as if he were a polygraph administrator who was questioning him. Carrying on his own little conversation, he continued, “Are you wearing a thong?” He then answered himself, “I am not wearing a thong.” He displayed many signs of disaffection, including boredom, disinterest, passivity, inattentiveness, distractibility, and mental disengagement. Only because of his involvement in the activities did he appear somewhat engaged.

During the post-treatment session, John appeared distracted and mentally disengaged, which implied disaffection. His involvement in the activities was the only sign of engagement. His mother requested that he be able to keep his 44 oz. soda with him because he felt as though he was getting a cold. Throughout the
session, this was a major distraction to him. He had a difficult time maintaining eye contact, and kept lying on the table, or resting his head in his hands.

Unlike the first two sessions, during the follow-up session, John displayed vitality, concentration, and involvement, which are signs of engagement, but displayed no signs of disaffection. However, he was still very fidgety throughout the session. A discussion of John’s story can be found in Chapter Five.

“Aaron.” This participant was an African American, 15 year-old male, who attended public high school. His younger sibling Blake, with whom he shared both biological parents, was also a participant in this study. On the parent pre-treatment questionnaire, his mother stated that when Aaron was four and a half, he began having difficulty focusing at school, staying on task, and finishing assignments. About a year after these symptoms presented themselves, Aaron started becoming very self conscious and critical of himself. He was getting upset because he felt as though he could not stay focused. They began talking to their doctor at that time, and at the age of six, he was diagnosed with combined type ADHD. He previously took the prescription stimulants Concerta and Ritalin, which were not effective. His mother shared that she was concerned about his lack of maturity, and more specifically his social maturity, when compared to his peers. She was also worried that opportunities would be limited for him because of his ADHD, and gave specific examples of him not being able to stay focused enough to play organized sports, and lacking the discipline needed to see tasks through. Her hope when enrolling him in this study was that the use of the brain games would help him be able to focus better
and stay on task. She also wanted him to feel better about himself, since she saw how self-conscious he was, and the low opinion he had of himself.

Responses to the participant pre-session questionnaire provided the following information. At the time of the study, Aaron was taking the prescription stimulant Adderall XR (20 mg) twice in the morning, and a 20 mg Adderall tablet in the evening. He indicated that he played video games for approximately six hours per day, seven days per week, and preferred action, adventure, and sports games. He did not consume caffeine on a regular basis, and had never been a smoker. No memory or speech loss had ever been sustained as the result of an injury to the head, and he did not participate in any sort of daily meditation or relaxation. He considered himself to be moderately active.

**SARAC.** On the pre-treatment SARAC, Aaron scored 69/80. His responses indicated that he listened well and tried his best in class, but felt worried at times, and found himself thinking about other things during.

Aaron’s score on the post-treatment SARAC was 55/80, which was 14 points lower than on the pre-treatment SARAC. At first glance, his responses implied that he was not putting forth as much effort as before, and did not find class to be as fun. However, there were quite a few inconsistencies. For instance, he answered “sort of true” that he tried hard to do well in school, as well as “sort of true” that he did just enough to get by. Since he expressed boredom and frustration in his last two entries prior to spring break, it seems probable that he was coming off of a bad week when he completed the post-treatment SARAC, which could have caused him to answer in a more negative way. This is one of the limitations of the SARAC; it is a “snapshot”
based on how the respondent is feeling at that moment. For Aaron, this snapshot did not concur with the more comprehensive view provided by his journal.

Aaron’s follow-up SARAC score was 61/80. His responses indicated that he still did not find class fun, but was trying harder than he had indicated on his post-treatment SARAC.

The disaggregation of his scores in Table 17 implies that throughout all three phases of the study, he considered himself behaviorally engaged, but tended to feel somewhat disaffected and emotionally disengaged.

Table 17

Disaggregation of Aaron’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre  Post  3-w</td>
<td>Pre  Post  3-w</td>
<td>Pre  Post  3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>20  18  19</td>
<td>16  12  14</td>
<td></td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>16  11  14</td>
<td>17  14  14</td>
<td></td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>36  29  33</td>
<td>33  26  28</td>
<td>69  55  61</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Three teachers submitted reports on Aaron’s behalf. The average of their pre-treatment TSARAC scores was 67/80. They were in general agreement that in class, he seemed interested, participated in discussions, and worked adequately, but often appeared worried or restless.

The average of Aaron’s post-treatment TSARAC scores went up 4 points, to 71/80. His teachers agreed that he seemed less worried, and was working even harder than before treatment.
On the follow-up TSARAC, the average of his teachers’ responses totaled 67/80, which was the same as the teacher average for the pre-treatment administration. All three teachers indicated that he was more anxious than during the treatment period, and two of the three indicated that he seemed unhappier since stopping the treatment. Table 18 shows the disaggregation of Aaron’s TSARAC scores.

Table 18

<table>
<thead>
<tr>
<th>TSARAC</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>Engagement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total (80)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
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<td>14</td>
<td>14</td>
<td>15</td>
<td>12</td>
<td>67</td>
<td>71</td>
<td>67</td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>14</td>
<td>15</td>
<td>15</td>
<td>25</td>
<td>27</td>
<td>26</td>
<td>67</td>
<td>71</td>
<td>67</td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>28</td>
<td>29</td>
<td>29</td>
<td>39</td>
<td>42</td>
<td>38</td>
<td>67</td>
<td>71</td>
<td>67</td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of point possible for that sub-category.

**FAB.** Aaron scored 16/18 on the pre-treatment FAB. He remained focused throughout the administration, and maintained good eye contact. Salmonella and sophisticated were two of his responses to prompt #2. These words were not typical of participant responses for this prompt, and implied that Aaron had a sizable vocabulary. One point was deducted from prompt #1 because he responded that a table and chair were alike since you use a chair to sit at a table, rather than responding that they were both furniture. One point was deducted from prompt #2 as well.

Aaron scored 17/18 on the post-treatment FAB. As with the first administration, the list of words he gave for prompt #2 indicated a much more advanced vocabulary than the other participants in the study. This list included the
words superficial, scrupulous, and superstitious. Having a good sense of humor, he added the nonsense word supercalifragilisticexpialidocious to his response. One point was deducted for prompt #4. Aaron was frustrated at himself for making the mistake, but again, showed good humor in his reaction.

EEG and video/reading questions. As shown in Table 19, after playing the brain games for five weeks, Aaron’s theta/beta ratio had decreased for three of the four VQ/RQ activities. During the follow-up EEG session, Aaron’s theta/beta ratios increased for all four VQ/RQ activities.

Table 19

<table>
<thead>
<tr>
<th>Aaron’s Theta/Beta Ratios</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>5.17</td>
<td>6.03</td>
<td>7.50</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>5.54</td>
<td>4.51</td>
<td>10.32</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>6.36</td>
<td>3.18</td>
<td>7.16</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>5.97</td>
<td>3.12</td>
<td>5.70</td>
</tr>
<tr>
<td>Mean</td>
<td>5.76</td>
<td>4.21</td>
<td>7.67</td>
</tr>
</tbody>
</table>

On the pre-treatment VQ/RQ, Aaron scored 12/20. His score increased to 14/20 at post-treatment, and again to 16/20 during the follow-up session.

Aaron’s scores over time. Figure 13 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Note how all of the instruments, with the exception of the SARAC, indicate an improvement for Aaron from pre-treatment to post-treatment. Additionally, his TSARAC and theta/beta ratio showed regression from post-treatment to follow-up, while the VQ/RQ and SARAC showed progress.
**Figure 13.** Aaron’s percentage of change on the quantitative instruments across sessions.

**Participant journal and NDSBA.** Aaron’s journal entries spanned the period from February 28 through March 28. He did not complete entries for the last four days of treatment. He did, however, resume his journal entries after returning from spring break, and completed them for two weeks. The entries indicated that he played on a total of 19 days, which coincides with the data retrieved from his NDSBA, increasing the trustworthiness of his responses. He indicated that he played for 20 minutes on each of those days, which is probable since the NDSBA data showed that he played an average of six games each day. Aaron’s entries appeared to be honest. For example, he reported on March 1 that he “didn’t exactly behave in 4th block,” and on April 12, stated that he was rude when people were presenting, because he was laughing.
A pattern emerged, and overall, it appeared that he felt better about school and was more able to focus at school, while he was playing the brain games. During the first three days of treatment, he reported that he was bored, tired, and did not show a lot of effort at school. Starting with the fourth day of treatment, his reports changed to express more positive feelings about school and better behavior in class. The negative feelings and behaviors were not reported again until March 18, and only appeared a total of three times from March 3 through March 28. After spring break, Aaron’s journal entries indicated that the negative feelings and behaviors had become more consistent, with reports of being bored on 4 of the 10 post-treatment school days, and “very jumpy” on another of them. For the other five days of the post-treatment period, Aaron noted that his behavior was good, and his feelings about school were “normal” or better.

**Participant interviews.** Aaron explained in his post-treatment interview that things had gone “pretty good” during the treatment period, and that his parents handed him his game each morning so that he would remember to play. He stated that he played away from distractions, and gave a “medium amount of effort” to the activities. Sometimes he felt like playing, and others he did not, but he played the game on all but six of the assigned days. He felt as though he was more focused at school, specifically stating that he could pay better attention in class, and talked less at inappropriate times. He predicted that during the weeks without treatment, he would still be able to pay better attention, even though he would not be playing the brain games.
During the follow-up interview, Aaron stated that he did not play any sort of brain games during the three weeks since the post-treatment session. He said he could tell a difference in his ability to focus since he stopped playing the games, and he caught himself playing around and talking to his friends more at school. He explained that it was still easier for him to focus than before playing the games, but that distractions were affecting him more than during the treatment period. This difference was realized when he returned to school after spring break. He said he had “no idea” if the games were what made the difference. He shared that he planned to resume the use of the games, and wanted to play them three times per week for 15-25 minutes each time. However, his parents made it clear that he would be playing the games more than he did during the study.

**Parent questionnaires.** On the parent post-treatment questionnaire, his mother indicated that she did not notice any significant change in Aaron’s behavior, attitude, or school performance. She stated that from their at-home observation, she did not feel the brain games helped treat his symptoms of ADHD. However, she said they planned to see if longer usage time and greater frequency had any positive effects. She also added that, “it would be interesting to understand if there is any correlation between puberty, or hormone changes, and the effects of the brain games.” This statement of curiosity made sense when considering the differences in the effect of the brain games on her two sons. This is further explained in the section about Blake.

Aaron’s mother stated, on the parent follow-up questionnaire, that she had noticed an immediate minor change in his behavior and attitude since stopping the
games, specifically that he was more difficult to wake up in the morning. She indicated that they had not seen a change in school performance since stopping the games, but explained that they do not get regular feedback from the teachers unless something significant happens. When discussing the results with the parents, Aaron’s father noted that after thinking about it, Aaron’s grades had come in, and they had gone up during the treatment period. During this conversation, Aaron was standing behind his parents who were sitting at the table with his brother, Blake, and the researcher. Aaron is very soft spoken, and does not seem as if he would brag on himself to his parents. For this reason, any progress could have been overlooked. Additionally, it is possible that Aaron’s improvements went unnoticed because Blake has more severe symptoms, and the family’s focus is often on improving his behavior, rather than Aaron’s. His parents indicated that they planned to continue the use of the games with extended use and increased frequency. They offered a suggestion that a future study could focus on how many times per day the games were played. For example, would playing the games after school help with homework?

**Researcher observations.** Aaron, along with his brother, was brought to all three sessions by both parents. During the first session, he presented as a neatly dressed, quiet, polite, young man. He consistently maintained good eye contact, and followed all instructions the first time they were given. There were no observable symptoms of ADHD. During the first session, he showed effort, concentration, involvement, and satisfaction, which are all signs of engagement. He displayed no signs of disaffection.
During the post-treatment session, Aaron displayed many signs of engagement, including pride, effort, concentration, and involvement. He did not appear disaffected in any way.

During the follow-up session, Aaron appeared engaged, showing effort, concentration, and involvement. As with the other two sessions, there were no signs of disaffection. A discussion of Aaron’s story can be found in Chapter Five.

“Blake.” This participant was an African American, 12 year-old male, who attended a public middle school. As mentioned in the previous section, Blake’s older brother was also a participant in the study. His mother stated on the parent pre-treatment questionnaire that Blake started showing symptoms of ADHD at the age of two. She said he was “like a tyrant”, easily agitated, with a minimal attention span, and far more hyper than most two year-olds. Two years later they spoke to a healthcare professional about the difficulties he was having controlling himself at school, and how he seemed very detached and distracted at home. He was diagnosed at the age of four with combined type ADHD, as well as oppositional defiant disorder, which is a pattern of disobedient, hostile, and defiant behavior toward authority figures (Kaneshiro, Benger, & Zieve, 2010). He has taken varying dosages of the prescription stimulant Adderall since being diagnosed. His mother was concerned about his reaction to the symptoms when he did not take the medication. She stated that he became extremely frustrated when he could not focus, and his hyperactivity resulted in irrational behaviors and him saying odd or mean things to people. Her hope in having him participate in this study was that the brain games would help him focus more naturally, despite any benefits received
from his medication. She also shared that he was socially immature, causing his peer interactions to be strained.

His responses on the participant pre-session questionnaire revealed the following information. At the time of the study, he was taking Adderall XR (30 mg) in the morning, and a 10 mg Adderall tablet in the evening. He indicated that he played video games four or five hours per day, about three days per week, and liked all genres of games. He did not regularly consume caffeine, and had never been a smoker. He indicated that he had never suffered memory or speech loss due to a concussion or blow to the head, and did not engage in any sort of daily meditation or relaxation. He considered himself to be moderately active.

**SARAC.** On the pre-treatment SARAC, Blake scored 67/80. Based on his responses, he felt he worked as hard as he could, and was fairly interested in class, but had difficulty with his mind wandering.

Blake scored 71/80 on the post-treatment SARAC, which was 4 points higher than on the first administration. Based on his answers, he was enjoying class more, listening more carefully, and thinking about other things less than he was before starting the treatment. However, he indicated feeling slightly more worried and discouraged. This could have been because he was more conscientious about his behaviors than before.

Blake’s follow-up SARAC score was 72/80. His responses indicated that he had reverted to feelings similar to those he had indicated prior to treatment with the brain games. He was enjoying class less than while he was playing them, but also
feeling less discouraged. Based on his responses, the amount of effort he was putting forth did not appear to change.

The disaggregation of Blake’s scores, as seen in Table 20, indicates that he makes a behavioral effort to remain engaged, and is challenged most by characteristics of disaffection.

Table 20

*Disaggregation of Blake’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores*

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post 3-w</td>
<td>Pre</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>19</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>17</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>36</td>
<td>40</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>71</td>
<td>72</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

*TSARAC.* Unfortunately, the TSARACs could not be used for Blake because they got mixed up in distribution. For instance, some teachers were given form #3 when it was time to complete form #2, and others completed two forms at one time.

*FAB.* Blake scored 16/18 on the pre-treatment FAB. During the administration, his eyes were moving all over the room. Aside from this fact, he displayed a considerable amount of focus. One point was deducted from prompt #1 because, like previous participants, he responded that a table and chair were alike because they were used in dining, rather than responding that they were both furniture. One point was deducted from prompt #3 as well.

On the post-treatment FAB, Blake scored 17/18. As on the first administration, one point was deducted from prompt #1 because he did not properly categorize table and chair as furniture. He was focused during the
administration, and although his eyes were moving around the room as they were during the pre-treatment session, there was more eye contact with the researcher during the post-treatment session than there had been during the pre-treatment session.

**EEG and video/reading questions.** Table 21 illustrates how for both VQ/RQ activities with no distraction, Blake’s post-treatment theta/beta ratios were lower than they had been during the pre-treatment session. However, for both activities with distraction, his ratios increased. During the follow-up EEG, Blake’s ratios for all four VQ/RQ activities had increased to higher than they were at the pre-treatment session.

Table 21

**Blake’s Theta/Beta Ratios**

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>5.03</td>
<td>5.02</td>
<td>7.74</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>4.92</td>
<td>5.41</td>
<td>7.74</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>5.67</td>
<td>4.82</td>
<td>9.05</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>5.30</td>
<td>5.93</td>
<td>6.42</td>
</tr>
<tr>
<td>Mean</td>
<td>5.23</td>
<td>5.30</td>
<td>7.74</td>
</tr>
</tbody>
</table>

Blake scored 12/20 on the pre-treatment VQ/RQ. His score increased by 1 point, to 13/20 on the post-treatment VQ/RQ, and again by 3 points, to 16/20 on the follow-up administration. There does not appear to be a noticeable relationship between his VQ/RQ scores and his theta/beta ratios.

**Blake’s scores over time.** Figure 14 represents the change in percentage of possible points scored for the SARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the
mean pre-treatment ratio. Note how Blake’s FAB, VQ/RQ, and SARAC all seemed to improve close to the same slight percentage from pre-treatment to post-treatment. Additionally, it is worth pointing out how drastically his theta/beta ratio increased from post-treatment to follow-up.

![Blake's Percentage of Change](image)

*Figure 14.* Blake’s percentage of change on the quantitative instruments across sessions.

**Participant journal and NDSBA.** Blake’s journal entries covered the entire treatment period from February 28 through April 1, as well as the follow-up period of April 11 through April 22. He reported that he played 20 minutes on each of the 25 assigned days. However, the NDSBA confirms what the mother stated, that there were two days on which he did not play. Because he was so contentious about playing every day, it is possible that when he got home from school on those two days, he did a brain age check, which is not recorded on the NDSBA calendar, and
recorded it as play time in his journal. It is not likely that Blake was trying to
mislead the researcher or be dishonest in any way. In fact, he played his game more
than any other participant in the study, averaging 7.5 games per session. So it is
possible that he actually played more than 20 minutes each day, but just recorded
20 minutes to show consistency. He also varied his play by including all nine games.
However, he had obvious favorites, as some were played 22 times, while others
were played much less.

There did not seem to be any emerging trends within Blake’s journal. His
entries from the beginning of the treatment period to the end of the follow-up
period revealed a student who felt enthusiastic about school on most days, and tried
to do well. However, there were some telling comments made. In several instances,
he noted that his least favorite class or classes were at the end of the day. This
would explain why his mother had received reports that his behavior changed
dramatically in the last two class periods of the day. Blake also mentioned that one
teacher always followed him around, and moved his seat when he talked, but did not
do that to the other students. On the second day of treatment, he claimed that he
thought the brain games kept him “in check.” During the second week of treatment,
he reported having a “high ear for learning.” One day later he stated, “I did better
than usual without (the) extra teachers my parents put on me to watch over
everything I do,” and “I’m happy to say with no extra teachers I was able to reach my
full work ethic and finish all my work today.” It appeared as though the extra
attention that he required had a very negative impact on his psyche, and he was
quite proud when he could control his behaviors, and limit the need for additional support.

**Participant interviews.** During the post-treatment interview, Blake stated that the five weeks of treatment had gone well, and that he remembered on his own to play his brain game each morning. He indicated that he was sometimes away from distractions when he played, that he put a good amount of effort into the games, and considered them fun. He believed that the games helped him get through the day, and that he was “less exhausted.” He predicted that he would be less focused during the following weeks since he would not be playing the games, and stated that he planned to continue their use once the follow-up period was over. He seemed proud, and shared that he had scored a brain age of 23 once.

Blake stated during the follow-up interview that he had not played any sort of brain games during the time since the post-treatment session. He indicated that he could tell a difference in his ability to focus, and was distracted, even in the classes where he was able to focus while playing the games. He said he felt as though he was better in the mornings than he was prior to using the brain games, but in a conversation with the parents, they made it clear that was not the case. He noticed the difference when he returned to school after spring break. However, his parents stated that they noticed the difference at home only two days after he stopped playing the games, adding that it was a dramatic change. Blake indicated he believed the use of brain games definitely had a positive effect on his ability to focus at school, and control his behavior at school and home. He said that he would resume playing the games for 30 minutes each school morning, and on some weekends.
**Parent questionnaires.** On the parent post-treatment questionnaire, Blake’s mother validated that he remembered to play the games on his own, and that he only missed two days because he woke up late. She conveyed how important it was to him to play each day. She stated that he seemed to be much calmer, less defiant, less agitated, and more on task than normal. This change was first noticed during the second week of treatment. She indicated that since he had always been academically strong, increased focus and intensity were the only differences she noticed in his school performance. She believed that the brain games helped treat his symptoms of ADHD and oppositional defiant disorder. She shared that, “He is generally at his worst first thing in the morning. The decrease in impulse behavior and him being less agitated were priceless.” She stated that she planned to implement the brain games as a permanent part of Blake’s morning routine, and possibly other parts of his day. She mentioned that, “At a recent school conference it came to light that Blake’s behavior changes significantly during his last two class periods.” She felt it might be worth investigating the length of time that the effects of the brain games have on the user, and was considering having him use the games each day after lunch, during the next school year.

During the follow-up period, prior to the final session, the researcher received an email from Blake’s mother stating, “Blake definitely NEEDS his brain game back... there is clearly a distinction between his ability to focus and control himself, and his participation in early morning brain games.” On the parent follow-up questionnaire, she indicated that one to two days after stopping the treatment, the participant “immediately became more agitated, easily irritated, unfocused (all
over the place).” She added that he had also become very antagonistic.

Approximately two to three days after returning from spring break, Blake’s parents received a significant increase of behavioral notifications from his school stating that he had been hyper, uncontrollable, loud, distracted, and disrespectful. His mother stated that she and his father felt the games were responsible for the positive improvements during the five weeks of treatment. She emphasized that they would resume the brain games immediately, with greater frequency and extended time periods. Because Blake’s reaction was so prominent, his parents thought it would be interesting to conduct a study on whether the use, and then cessation, of brain games can cause withdrawal effects similar to the terminated use of stimulants.

**Researcher observations.** Blake and his brother were brought to all three lab sessions by their mother and father. During the pre-treatment session, Blake presented as a neatly dressed, very polite, and well-behaved, young man. He had difficulty maintaining eye contact, not only with the researcher, but also in general. When he spoke, it was in short, choppy bursts, and there was often a little smirk that hinted he wanted to laugh, but for some reason, did not. Regardless of having been diagnosed with oppositional defiant disorder, he did not show signs of opposition to the researcher. Through his concentration and involvement he appeared engaged. Although he seemed a little passive, which is a sign of disaffection, the researcher felt as though this could have been just a relaxed effect from his medication.

During the post-treatment session, Blake displayed interest, pride, concentration, and involvement, which are all signs of engagement. As in the pre-
Brain Games and ADHD

treatment session, his passive nature hinted at disaffection, but again was believed by the researcher to be more of a side effect of his medication. Specifically, he showed interest in things such as what his brain pictures from the first session looked like.

At the follow-up session, Blake was very interested in, and kept asking questions about, details pertaining to the study. He was much more talkative than during the first two sessions. Throughout all three sessions, he had the same little smirk that hinted he wanted to laugh. During the final session, the researcher asked him about it. He indicated that he had learned to hold back his laughter because he often got in trouble for it. The passive appearance that had been present during the first two sessions did not surface during the follow-up session. The only characteristic displayed by Blake that could be found on the disaffection checklist was “distracted,” and that was just because he kept asking questions about the study. Conversely, he showed full engagement, in the form of interest, concentration, involvement, and pride. A discussion of Blake’s story can be found in Chapter Five.

“Caleb.” This participant was a Caucasian, 10 year-old male, who attended a public elementary school. His mother indicated on the parent pre-treatment questionnaire that Caleb’s teachers had expressed a concern about his behavior when he was in kindergarten, but she did not see it as abnormal because he was her first child. Because of his struggles at school, which included losing homework and forgetting what needed to be done, he saw various healthcare professionals from the time he was in kindergarten. His mom stated that some of the health care professionals did not seem convinced that he had ADHD, and she wanted to be very
sure before labeling him, so he was not officially diagnosed with combined type ADHD until the age of nine. Caleb began taking the prescription stimulant Adderall at that time, and his mother indicated she saw an immediate improvement. She shared that she was concerned about the prospect of him taking medication for his entire life, and the potential problems that his behavior could cause. Her hope in allowing him to participate in this study was that they would find an alternative to medication for treating his ADHD symptoms. She also shared that he did better when a structure or routine was in place, and was hopeful that the routine of playing the brain games each morning would benefit him.

At the time of the study, Caleb was taking 10 mg of Adderall daily, which his mother described as “just enough to get by.” Through his responses on the participant pre-session questionnaire, he shared the following information. He played approximately three hours of video games per weekday, and five or more hours each day on the weekend. He preferred action, adventure, and fighting games. Caleb stated that he did regularly consume caffeine, but had never been a smoker. He indicated that he had never suffered memory or speech loss due to a head injury, and did not engage in regular meditation or relaxation. He considered himself to be moderately active.

**SARAC.** On the pre-treatment SARAC, Caleb scored 52/80. His responses indicated that he worked hard in class, but thought about other things and found class boring.

Caleb scored 74/80 on the post-treatment SARAC, which was 22 points higher than on the pre-treatment SARAC. Based on his responses, he was enjoying
class more, working harder, and thinking about other things less than he was prior to the treatment period.

On the follow-up SARAC, Caleb scored 65/80, which was 9 points lower than on the post-treatment SARAC. Based on his responses, he was not enjoying class as much as during the treatment period, and was thinking about other things more.

Based on the disaggregation of his scores, shown in Table 22, there was an improvement in the characteristics of engagement for all four of the sub-categories, but most noticeably emotional disaffection. Additionally, after ceasing the use of the brain games, his greatest regression was in the area of emotional disaffection.

Table 22

**Disaggregation of Caleb’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores**

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>17</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>14</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>31</td>
<td>38</td>
<td>36</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Since Caleb was in the 5th grade, he only had one teacher to complete the TSARAC. His teacher’s responses on the pre-treatment TSARAC totaled 54/80. She indicated that he did not work very hard, was often unprepared, seemed restless, and did not listen very carefully.

His teacher’s post-treatment TSARAC score was 59/80, which was five points higher than on the first administration. Her responses indicated that he was working harder and was more prepared than he was prior to the treatment period.
On the follow-up TSARAC, his teacher’s total was 62/80, which was still 3 points higher than on the post-treatment TSARAC. Her responses indicated that, although he did not seem to be as enthusiastic as he was during the treatment period, he did not appear as anxious, and was listening more. Table 23 shows the disaggregation of Caleb’s TSARAC scores.

Table 23

Disaggregation of Caleb’s Pre-treatment, Post-treatment, and 3-Week Follow-up TSARAC Scores

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre  Post</td>
<td>Pre  Post</td>
<td>Pre Post 3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>8   10   12</td>
<td>8   11   11</td>
<td></td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>13  14   12</td>
<td>25  24   27</td>
<td></td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>21  24   24</td>
<td>33  35   38</td>
<td>54  59   62</td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of point possible for that sub-category.

**FAB.** Caleb scored 9/18 on the pre-treatment FAB. Prior to starting the assessment, when the researcher explained that she would be providing instructions or prompts for him to follow, he stated, “I can only follow directions if they’re fun.” One point was deducted from prompt #1 because he responded that a table and chair were alike since they both have legs, rather than saying they were furniture, as the battery requires for full credit. Caleb seemed hyper and unfocused while trying to think of words to list for prompt #2, and only scored one of the three possible points for that prompt. During prompt #3, he was not able to complete more than one correct series in a row, but it was difficult to tell how many of his errors were due to silliness rather than legitimate inability to focus on the task. Every time he would make a mistake he would slap his forehead or make a noise of frustration. These same behaviors were present during the remainder of the
battery. Additionally, two points were deducted from prompt #4, and one point was deducted from prompt #5.

On the post-treatment FAB, Caleb scored 16/18, which was 7 points higher than he scored on the pre-treatment battery. As on the first FAB, one point was deducted from prompt #1 for answering that a table and chair were alike because they had legs and were found in a kitchen. One point was also deducted from prompt #3. On the other hand, the list of words he gave in response to prompt #2 was more than twice the length of the list he gave during the first administration, and he received full points for this prompt the second time.

**EEG and video/reading questions.** Table 24 illustrates that from pre-treatment to post-treatment, Caleb’s theta/beta ratio decreased during three of the four VQ/RQ activities. Follow-up ratios for the same three activities were even lower than at post-treatment. His mean ratio also decreased from pre-treatment to post-treatment, and again during the follow-up session.

Table 24

<table>
<thead>
<tr>
<th>Caleb’s Theta/Beta Ratios</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>9.38</td>
<td>9.12</td>
<td>8.90</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>9.94</td>
<td>8.61</td>
<td>7.86</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>9.14</td>
<td>9.33</td>
<td>10.01</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>10.02</td>
<td>8.26</td>
<td>7.86</td>
</tr>
<tr>
<td>Mean</td>
<td>9.62</td>
<td>8.83</td>
<td>8.66</td>
</tr>
</tbody>
</table>

Caleb only scored 7/20 on the pre-treatment VQ/RQ. His score increased to 15/20 on the post-treatment administration. During the follow-up session, his VQ/RQ score decreased to 12/20.
Caleb’s scores over time. Figure 15 represents the change in percentage of possible points scored for the SARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. As illustrated in Figure 15, Caleb’s SARAC, FAB, and VQ/RQ scores all had a similar percentage of increase from pre-treatment to post-treatment. His TSARAC and theta/beta ratio also showed improvement, just not to the same extent as the others. From post-treatment to follow-up, there was regression in his SARAC and VQ/RQ, but continued improvement in his theta/beta ratio and TSARAC.

![Caleb's Percentage of Change](image)

*Figure 15. Caleb’s percentage of change on the quantitative instruments across sessions.*

**Participant journal and NDSBA.** Caleb’s journal entries included all except for the last day of the treatment period, and all but the last day of the follow-up
period. On 17 days, he reported playing for 20 minutes, and on 3 days, for 18 minutes. Data retrieved from his NDSBA validated that he played a total of 20 of the 25 assigned days. With an average of 4.2 games per session, it is possible that he played for 18 or 20 minutes each time. He played each game at least once, but had three apparent favorites that were played 18 times each.

His journal entries showed no emergence of an engagement pattern from the beginning to the end of the treatment period. However, during the treatment period, he only indicated having negative feelings or behaviors at school on 13% of the days, whereas during the follow-up period, negative feelings or behaviors were reported on 44% of the days. This could be an indicator that the use of brain games had a positive impact on his classroom engagement. It appears that he was honest in his journal entries. For instance, on one particular day, he detailed that he had been in a little social trouble, called two girls gay, said hell, and struggled with self-control. On a different occasion, he indicated that he felt guilty about something from the past that had been “eating at” him, and it had affected his engagement at school that day.

**Participant interviews.** During the post-treatment interview, Caleb indicated that overall, the five weeks of treatment had been about the same as always; he had good days and bad days. He stated that he usually remembered to play the brain games on his own, but had to be reminded by his mother a few times. He described how he usually played the games in his mother’s room, away from distraction. He said that he put effort into the games, and enjoyed playing them. Caleb surmised that the games had helped him with his math skills, and “maybe a
little bit with focus.” He mentioned that his mother transcribed his journal for him each evening. However, her knowledge of his school behavior did not appear to affect the honesty of his statements. He predicted that during the weeks in which he would not be playing the games, his class engagement would not be any different than it was when he was playing them.

Caleb indicated, during the follow-up interview, that he did not play any sort of brain game during the three weeks following the treatment period. He stated that he felt a little less focused, and as if he got angry more easily than during the treatment period. He stated that he would resume playing the brain games if his mother forced him, but that he would rather play a different brain game than Brain Age.

*Parent questionnaires.* On the parent post-treatment questionnaire, Caleb’s mother indicated that he showed initiative in playing his brain games each morning, was always eager, and had a great attitude about playing them. She stated that she did not really notice a change in his behavior or attitude during the treatment period. She expressed that, “towards the end he was a lot more focused and calm,” but added that it could have been because he was trying to show maturity so she would buy him some video games that were rated for older kids. She said that she had not seen an improvement in school performance because he had been a consistent straight A student the entire school year. At the time of the post-treatment session, she had not decided whether or not she would have Caleb resume the use of the brain games after the study.
Caleb’s mother indicated, on the parent follow-up questionnaire, that she noticed a change in his behavior during the first few days of school following spring break, but was not sure if it was because he had stopped playing the games, or if he was tired from spring break. She said she intended for him to resume playing the games because she felt, “it was a good way to start off focusing his day.” Since he had maintained good grades throughout the school year, she did not notice a change in his school performance. However, she said that aside from helping with his math skills, she felt that playing the games in the mornings helped prepare his mind for school. She also expressed how she believed the routine of playing helped settle him, and that he had a calmer demeanor and confidence during the treatment period.

**Researcher observations.** Caleb was brought to all three lab sessions by his mother, who was also accompanied by Caleb’s younger sister. On the day of his pre-treatment session, his mother stated that he had not taken his medication that morning because he woke up late, and she did not want the medicine to cause him to be up late that night. With that in mind, he presented as an extremely hyperactive and immature child. He consistently interrupted the researcher and his mother when they were speaking. During the session, he was inattentive, distracted, mentally disengaged, and frustrated at times, which are all signs of disaffection. His vitality and involvement were the only signs of engagement.

When Caleb arrived for his post-treatment session, his mother informed the researcher that, unlike the morning of the pre-treatment session, he had taken his medication. Throughout the session, Caleb displayed effort, concentration, and
involvement, which are signs of engagement. He was more focused than during the first session. However, his anxiety and passivity hinted at disaffection. When the researcher was setting him up for the EEG, and explained that she was connecting the electrodes, he said, “Please do not say electrodes,” and then added something about lightening and electricity near his brain. Some of his social interactions mirror those of someone with Asperger Syndrome, which is a disorder typified by weak social functioning and inability to recognize the viewpoints of others (Salend, 2011).

During the follow-up session, Caleb displayed involvement and concentration, which are signs of engagement. However, at the beginning of the session, he was distracted because he wanted to spin in the chair in which his sister was sitting while the researcher was talking to him and his mother. Additionally, he got frustrated with the presentation of distractions during the RQ and VQ. Both of these are signs of disaffection. The researcher believes many of his behaviors could have been exacerbated by his lack of maturity. A discussion of Caleb’s story can be found in Chapter Five.

“Dante.” This participant was a Caucasian, 13 year-old male, who attended a private school specifically for students with ADHD and learning disabilities. His mother stated on the parent pre-treatment questionnaire that she first became concerned about his behavior when he was 18 months old because he was constantly in motion. When Dante was in the 1st grade, he suddenly began exhibiting symptoms of obsessive-compulsive disorder (OCD), and was having a difficult time at school, so his mother took him to see a health care provider. He was diagnosed at the age of six with a moderately severe case of combined type ADHD, as well as OCD.
He started taking stimulant medication in the 1st grade, but as a result, developed a tic at the end of 5th grade, and had to discontinue taking the medication for a year and a half. During that time, he experienced extreme academic and behavioral problems in school. Dante’s mother was concerned about his ability to be successful in life. She stated that he was very bright, but the ADHD affected his ability to demonstrate how smart he was since it caused him to lack impulse control, motivation, executive functioning, and ability to focus or concentrate. She enrolled him in this study with hopes that the brain games would strengthen his ability to focus and control his impulses.

His mother stated that, at the time of the study, Dante was taking the prescription antidepressant Wellbutrin (300 mg) which can be used to treat ADHD in those who are not tolerant of stimulant medication (Nazario, 2009). He was also taking Zoloft (75 mg) to treat his OCD. Dante indicated on his participant pre-session questionnaire that he regularly played video games, but apparently overlooked the question that asked how many hours and how many days per week. His mother subsequently emailed the researcher the details, saying that he usually played two days per week for two hours each day, and preferred to play games in the action, adventure, and sports genres. On the pre-session questionnaire, Dante also stated that he did not regularly consume caffeine, and had never been a smoker. He had never suffered memory or speech loss due to a blow to the head, and did not engage in any sort of daily meditation or relaxation. Since he played baseball, he considered himself to be highly active.
**SARAC.** On the pre-treatment SARAC, Dante scored 42/80. His responses indicated that he did not enjoy class, did not listen carefully, and often thought about other things. However, his answers to the prompts that described his actual level of effort in class were conflicting. For instance, he responded that it is “sort of true” that he just acted like he was working in class, and “very true” that he did just enough to get by, but then answered “sort of true” that he tried hard to do well in school, and worked as hard as he could. It appeared that, in his mind, that level of effort constituted “trying.”

Dante scored 43/80 on the post-treatment SARAC. His responses indicated that, during the treatment period, he was not feeling quite as good in class, but that he was trying a little harder than he was prior to the treatment period.

Dante’s follow-up SARAC score was 37/80, which was 6 points lower than on his post-treatment SARAC. His responses were conflicting in many cases. For instance, he responded “very true” that he tried hard to do well in school, and “very true” that he did not try hard at school. Additionally, he answered “not at all true” that he felt bad in class, but “not very true” that he felt good. Another example is that he indicated it is “sort of true” that he paid attention in class, but “not at all true” that he listened carefully. Because of these conflicting responses, the trustworthiness of his follow-up SARAC was compromised. Table 25 shows the disaggregation of Dante’s SARAC scores.
Table 25

*Disaggregation of Dante's Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores*

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th></th>
<th></th>
<th>Disaffection</th>
<th></th>
<th></th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td></td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>9</td>
<td>11</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>19</td>
<td>18</td>
<td>19</td>
<td>23</td>
<td>25</td>
<td>18</td>
<td>42  43  37</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Three teachers submitted the pre-treatment TSARAC on Dante’s behalf. The average of their scores was 42/80, exactly what Dante scored himself. The teachers were in general agreement that he seemed uninterested, came to class unprepared, appeared restless, and thought about other things in class. His math teacher scored him lower in many areas, including his level of anxiety, anger, and how he feels in her class.

On the post-treatment TSARAC, the average was 45/80, three points higher than on the pre-treatment TSARAC. Dante’s math and literature teachers indicated that he seemed more interested in class, and was working harder than he was prior to the treatment. His world cultures teacher, on the other hand, indicated that he was not working quite as hard, and was a little more distracted than when she completed the first TSARAC.

Unfortunately, the trustworthiness of the follow-up TSARAC is in question. All three of Dante’s teachers submitted the same responses on their electronically submitted follow-up TSARAC reports as they did on the post-treatment TSARAC. It appears as if they just saved their answers from the post-treatment submission and resubmitted them. For this reason, there is limited value in the results from their
follow-up submissions, as it is virtually impossible that there could have been
absolutely no change in all three of his classes. Needless to say, the average of their
scores was 45/80, as it was on the post-treatment administration.

When comparing the disaggregated pre-treatment and post-treatment
TSARACs, as seen in Table 26, it appears as though Dante's teachers felt both his
behavioral and emotional engagement had improved during the treatment period.
However, his emotional disaffection decreased slightly.

Table 26

Disaggregation of Dante's Pre-treatment, Post-treatment, and 3-Week Follow-up
TSARAC Scores

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (out of 80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>7</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>8</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of point possible for that sub-category.

FAB. Dante scored 10/18 on the pre-treatment FAB. His low score appeared
to be caused by his lack of attention to the researcher's instructions. Two points
were deducted from prompt #1. One point was deducted because instead of
categorizing a banana and an orange as fruit, he answered that they were alike since
you could peel both of them. The other point was deducted because instead of
categorizing a table and chair as furniture, he responded that they were both wood.
Additionally, one point was deducted from prompt #3, two points from prompt #5,
and all three points were deducted from prompt #4.

On the post-treatment FAB, Dante scored 11/18, only 1 point higher than on
the first administration. During the administration of this instrument, and
throughout the rest of the session as well, he appeared distracted and mentally disengaged. For prompt #1, all three possible points were deducted. He stated that a banana and an orange were alike because they tasted good, instead of categorizing them as fruits. He responded that you sat on a table and chair, instead of categorizing them as furniture. Lastly, he answered that a tulip, rose, and daisy were alike because they were in the ground, rather than categorizing them as flowers. Additionally, one point was deducted from prompt #3, and all 3 points were deducted from prompt #4.

**EEG and video/reading questions.** As can be seen in Table 27, from pre-treatment to post-treatment, there was a decrease in Dante’s theta/beta ratio for all four VQ/RQ activities. Conversely, from post-treatment to follow-up, ratios for all four activities decreased.

Table 27

<table>
<thead>
<tr>
<th>Dante’s Theta/Beta Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Reading – no distraction</td>
</tr>
<tr>
<td>Reading with distraction</td>
</tr>
<tr>
<td>Video – no distraction</td>
</tr>
<tr>
<td>Video with distraction</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

Dante scored 11/20 on the pre-treatment VQ/RQ. He increased his score by 2 on the post-treatment administration, for a total of 13/20. On the follow-up VQ/RQ, his score again increased by 2 for a total of 15/20.

**Dante’s scores over time.** Figure 16 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in
mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. As can be seen in Figure X, aside from the changes in Dante’s theta/beta ratio over the course of the study, there was not much of a change in his scores.

![Dante's Percentage of Change](image)

*Figure 16.* Dante’s percentage of change on the quantitative instruments across sessions.

**Participant journal and NDSBA.** Unfortunately, there was a large amount of inconsistency between Dante’s journal entries, and the information collected from his NDSBA. He completed entries for all 25 of the assigned treatment days, but not for the two weeks of no treatment following spring break. On 14 of the assigned days, he reported that he played for 20 minutes, and on five others, just wrote “yes.” He also reported not playing on six days because he was out of town, did not go to school, or did not have the game with him on the bus. However, when the data was
retrieved from his NDSBA, it showed that he only played on four of the assigned days, and one weekend day. The researcher called Dante’s mother and asked to speak to Dante. The researcher explained to him that she would not be mad at him for not playing, but that to make sure that she had accurate information for the study, she needed to know the truth. He insisted that he played more than the five days that the NDSBA calendar was showing. After talking to Dante for a few minutes, the researcher realized that on 10 days, he had completed the brain age check instead of playing the games in the training mode. He expressed that he was confused, and thought that he could choose either the brain age check or the training program each day. The Brain Age software does not record the specific dates on which a brain age check is completed, but does show how many times it has been done. Therefore, in all, it was assumed that he played some sort of brain game on 14 of the assigned days. Since Dante explained why he did not play on six of the assigned days, it appears that the five days when he just wrote, “yes” in the minutes column, were the days when he did not really play at all. Additionally, since a brain age check is comprised of only three games, when combined with the number of times he played each of the games in the training program, he played an average of 2.9 games per session. Therefore, it is not likely that he actually played for 20 minutes each time. All of these factors limit the trustworthiness of his journal entries. As far as the variety of games played, he played six of the training games from one to four times each, and did not play the other three at all.

Aside from the fact that his journal entries lacked trustworthiness, there were no observable patterns or trends found within the entries. On 8 of the 25 days
during the treatment period, Dante reported feeling bored or angry at school, and indicated he felt interested or enthusiastic on the other 17 days. On 9 of the 25 days, he reported that he had difficulties with his behavior at school, including being distracted, off task, and not putting forth effort. On the remaining 16 days, he claimed to have shown effort and had good concentration. He indicated on two days that he had not felt like eating, and did not show his best behavior on those days. Again, however, all of this information appeared to be randomly dispersed throughout the five week time period, and there were no evident patterns or trends.

**Participant interviews.** During the post-treatment interview, Dante indicated that he played the brain games as requested, but “lost it one day.” Because he attended a private school that required an hour of travel both to and from school, his mother had requested that he be able to play the games on the bus in the mornings. Dante explained that he wore the provided earbuds to help block out distraction. He stated that he put effort into the games, but as far as enjoying playing them, they were just “okay.” He claimed that he felt better during the treatment period, and said that he stayed on task, and did not get in as much trouble. His mother transcribed his journals for him each evening, but this did not appear to influence the honesty of his reports about school. He expressed that he was not sure how it would affect him to stop playing the games for three weeks.

During the follow-up interview, Dante confirmed that he had not played any brain games during the three weeks since the post-treatment session. He indicated that after stopping the games, he seemed to get angry faster. However, he also mentioned that the doctor had recently switched his prescription medication from
Zoloft to Prozac, which could have also caused a change in his temperament or mood. He stated that he had not decided whether he would resume playing the brain games, and added that he had just slept on the bus since he had stopped playing them.

**Parent questionnaires.** On the parent post-treatment questionnaire, his mother stated that she thought he had played the brain games daily on the bus, but knew he left it at school a couple of times. She indicated that she reminded him each morning to play, but could not control whether he actually did or not since he was not under her supervision while riding the bus. She stated that, at the beginning of the treatment period, his behavior and attitude would improve, and then get worse. However, she said the last two weeks of treatment were consistently good, and the fifth week was his best school week ever. Additionally, his school performance was consistently better during weeks four and five of treatment. She explained that, at first, she did not think the brain games were helping, but then added, “now that I’ve seen such a dramatic improvement I’ve changed my mind.” With that in mind, it was surprising to the researcher when she indicated that she was not sure if she would have him resume the use of the games after the follow-up period.

On the parent follow-up questionnaire, Dante’s mother stated, “Dante’s behavior and attitude improved greatly over the past several weeks. He has continued and sustained these improvements since he stopped playing the Brain Age.” She added that his school performance had also greatly improved in the weeks prior to the follow-up session, and that he had maintained those improvements as well. Specifically, she shared that he had come up several levels on his school’s
Brain Games and ADHD

performance and behavior rating scale. Regarding her feelings about the effects of using brain games, she responded, “Unfortunately, he was not playing as instructed – it’s hard to know what has contributed to his improvements.” She indicated that she wanted him to resume playing the games if he would comply. At the end of the questionnaire she added:

I look forward to hearing your results. I feel badly that Dante did not play as instructed and that I did not realize it until it was too late. I’m so happy with the huge improvement he has made at school and home. He went from consistently failing his point sheets, where we even had to meet with the headmaster to determine if he would remain at the school, to passing with flying colors. His attitude at home has also shown huge improvements.

**Researcher observations.** Dante was brought to all three sessions by his mother. During the pre-treatment session, he presented as a quiet, and possibly unhappy, young man. He kept his hood on his head until it was time to connect him to the EEG, and was slouched in his seat for most of the session. As the session progressed, he did warm up to the researcher. However, he continued to appear bored, sad, withdrawn, and mentally disengaged, which suggested disaffection. Engagement was merely observed through his involvement in the activities.

During the post-treatment session, Dante appeared bored, distracted, and mentally disengaged, which are all signs of disaffection. He was involved, which was the only indicator of engagement. He did share that he had gotten hit in the forehead with a baseball bat, and showed the researcher his injury.
Dante was very active, fidgety, and somewhat antagonistic or defiant during the follow-up session. For instance, during the VQ video, he pretended to be asleep. During the second half of the video, when the researcher provided distraction, he asked if she had to do the distraction. When she told him yes, she had to provide distraction, he plugged his ears, and started clicking a pen. Before the RQ with distraction, he asked if the researcher would be distracting him again. When she answered yes, he started waving the laminated reading card, which made a loud sound. When told to stop waving the card and read, he replied, “You’re doing it.” The researcher had not corrected him about the pen clicking, but it was not possible for him to read the selection while waving the page, so she told him to please stop and read. Additionally, he kept trying to touch the wires that were attached to the EEG cap on his head. Throughout the session, he displayed many signs of disaffection, including boredom, disinterest, passivity, frustration, distractibility, and mental disengagement. The only indicators of engagement were his involvement in the activities, and his absorption of the video and reading material. This was evidenced by the fact that he answered 15 of the 20 VQ and RQ questions correctly. Considering his behavior during the session, the researcher was surprised that he was able to recall 75% of the details from the video and readings. A discussion of Dante’s story can be found in Chapter Five.

“Eli.” This participant was a Caucasian, 12 year-old male, who, at the time of the study, had just re-enrolled in a public middle school after being home schooled for four and a half months. On the parent pre-treatment questionnaire, his mother indicated that she started noticing the symptoms of ADHD at the age of three, noting
that he never stayed focused on one activity for very long, he was always “on the
go”, and was extremely impulsive. From the beginning, she shared the behaviors she
was witnessing with his pediatrician, and he was diagnosed at the age of five with
combined type ADHD. Since his diagnosis, they have tried many medications, and
made many adjustments along the way. Her main concern was that Eli was
extremely impulsive, which affected him in social situations. She was also concerned
about how much he “spaced out” at school. Her hopes for enrolling him in this study
were that they would see an improvement from the use of the brain games, and
would be able to try discontinuing the medication he was taking at the time of the
study.

Eli’s mother stated that he takes the prescription non-stimulant Intuniv (3
mg) daily to treat his ADHD symptoms. Through his responses on the participant
pre-session questionnaire, Eli revealed the following information. He played video
games two days per week, for about one hour each day. He preferred action games,
but played some brain games. He did not regularly consume caffeine, and had never
been a smoker. He had never suffered memory or speech loss due to a head injury,
and did not engage in any sort of daily meditation or relaxation. Being a baseball
player, he considered himself to be moderately active.

**SARAC.** Eli scored 57/80 on the pre-treatment SARAC. His responses
indicated that he did not consider class to be fun, and that he did not get involved in
class, or participate in discussions. On the other hand, he responded that he did try
to do well in school.
On the post-treatment SARAC, Eli scored 59/80, which was only 2 points higher than on the pre-treatment SARAC. Based on his responses, he was enjoying class more, but was also thinking about other things more often, and not trying quite as hard as he had been.

Eli’s follow-up SARAC score was 61/80, which was 2 points higher than on the post-treatment administration. His responses indicated that he was trying a little harder to do well, but was not enjoying class as much as during the treatment period.

Based on the disaggregation of his scores, as seen in Table 28, it is possible that the treatment helped him feel better emotionally about class, but did not necessarily help improve his behavior while in class.

Table 28

*Disaggregation of Eli’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores*

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>15</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>11</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>26</td>
<td>28</td>
<td>29</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Three teachers returned the TSARAC on Eli’s behalf. The average of their scores was 55/80, which was relatively close to the total of his own assessment. In general, they appeared to agree that he did not listen carefully or pay attention in class, and did not work as hard as he could. They also concurred that he seemed to feel good in class, and appeared to be interested.
On the post-treatment TSARAC, his teachers’ average went down 3 points to 52/80. They seemed to be in general agreement that he did not pay attention in class, seemed restless, and thought about other things. They also indicated that he did not work as hard as he could, and seemed to do just enough to get by.

His teachers’ average dropped an additional 8 points, to 44/80, on the follow-up TSARAC. They all agreed that Eli seemed restless and anxious, and often thought about other things. Their responses also indicated that he was coming to class more unprepared, and seemed less interested, than during the treatment period. Table 29 shows the disaggregation of Eli’s TSARAC scores.

Table 29

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre  Post 3-w</td>
<td>Pre  Post 3-w</td>
<td>Pre  Post 3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>9    9 8</td>
<td>10 6 5</td>
<td></td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>12 11 10</td>
<td>24 26 21</td>
<td></td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>21 20 18</td>
<td>34 32 26</td>
<td>55 52 44</td>
</tr>
</tbody>
</table>

*Note. Numbers in parentheses are the number of point possible for that sub-category.*

**FAB.** On the pre-treatment FAB, Eli scored 16/18. One point was deducted from prompt #1 because he responded that a table and chair were alike since you put things on them, rather than categorizing them as furniture. One point was also deducted from prompt #5.

Eli scored 17/18 on the post-treatment FAB, which was 1 point higher than on the pre-treatment FAB. One point was deducted from prompt #5. He also lost one point on this prompt the first time. As can be seen in Appendix C, prompt #5 tests a participant’s inhibitory control.
**EEG and video/reading questions.** As seen in Table 30, Eli’s theta/beta ratio decreased for three of the four VQ/RQ activities, from pre-treatment to post-treatment. For those same three activities, his ratios increased during the follow-up session. The video activity, for which the ratio had increased at the post-treatment session, saw a decrease at the follow-up session. Eli’s mean theta/beta ratios show a decrease from pre-treatment to post-treatment, with a small increase at the follow-up.

Table 30

<table>
<thead>
<tr>
<th>Eli’s Theta/Beta Ratios</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>6.66</td>
<td>5.28</td>
<td>6.57</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>5.74</td>
<td>0.48</td>
<td>5.57</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>7.47</td>
<td>7.81</td>
<td>5.98</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>23.25</td>
<td>6.56</td>
<td>6.57</td>
</tr>
<tr>
<td>Mean</td>
<td>10.78</td>
<td>5.03</td>
<td>6.17</td>
</tr>
</tbody>
</table>

Eli scored 12/20 on the pre-treatment VQ/RQ. His score decreased to 8/20 on the post-treatment assessment. On the follow-up assessment, his score increased 2 points to 10/20.

**Eli’s scores over time.** Figure 17 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Although Eli’s theta/beta ratio decreased from pre-treatment to post-treatment, his VQ/RQ and TSARAC scores did as well. However, his FAB and SARAC scores increased slightly.
Figure 17. Eli’s percentage of change on the quantitative instruments across sessions.

**Participant journal and NDSBA.** Although the data retrieved from Eli’s NDSBA showed that Eli played on 24 out of the 25 assigned treatment days, his journal only contained entries for 16 of those days. He also completed entries for the first two days following spring break, but no more after that. He reported in his journal that he played 20 minutes on 12 of the days, and a little more or less on 4 of them. His responses to the journal prompts were very short, and rarely longer than two words. For all of the days during the treatment period, he reported that his feelings about school, and his behavior at school, were good, and sometimes added that he was enthusiastic or showed effort. On the very first day of treatment, he reported that he felt satisfied about school that day, and had shown effort, but that he was distracted. That was the only time he mentioned being distracted in the
entire journal. There was one four-day period where he mentioned being tired or sleepy each day, and another day when he stated that he had been bored in language arts. Other than those instances, there were no negative emotions or behaviors reported during the treatment period. However, both of the journal entries that followed spring break contained reports of boredom.

As stated earlier, the NDSBA data show that Eli played on 24 of the 25 assigned treatment days. Overall, he played a good variety of games, and only had two that he did not play at all. He played an average of 3.1 games per session. This suggests that he probably played for 15 rather than 20 minutes each day, which corresponds with the information that his mother provided.

**Participant interviews.** During the post-treatment interview, Eli stated that half of the time he remembered to play the brain games on his own, but the rest of the time he had to be reminded. He indicated that some of the time he was away from distraction, but that his brother distracted him at other times. He claimed to have put a good amount of effort into the activities and enjoyed playing each morning. He stated that he could not tell a difference at school, and that he had been “pretty off task”. When the researcher asked him how he became aware that he was off task, he clarified that the other students told him, which indicates that he knows he can be a distraction to the other students in the class. He predicted that he would not see a difference during the three weeks when he would not be playing the games.

Eli verified, during the follow-up interview, that he had not played any brain games during the three weeks since the post-treatment session. He indicated that he
could not tell any difference in his ability to focus at school or engage in class since stopping the games. He said that although he did not feel that playing the brain games made any difference in his ability to manage his symptoms of ADHD, he planned to resume playing them for 15 minutes each school morning.

**Parent questionnaires.** On the parent post-treatment questionnaire, Eli’s mother stated that he played at least 15 minutes every day, but needed to be reminded to play. She expressed that, in the beginning, he was excited to play, but starting with the second week, it became more of a chore to him. She indicated that she did not see any improvement in school performance, and did not really notice any difference in his behaviors, adding that he was still very impulsive and “scatter-brained.” She said that she would like for him to continue playing the games after the study, but that it was not worth fighting over. She also explained that they had recently noticed that Eli’s ADHD medication had become ineffective, and they had seen an increase in his lack of organization, impulsivity, and unreliability. She added, “However, when Eli stops and takes some time to study, it soaks in like a sponge. Not sure if that’s from Brain Age or not.”

Eli’s mother stated, on the follow-up questionnaire, that she had not noticed any change in his behavior or attitude since he stopped playing the games. However, she indicated that she had noticed a difference in his school performance starting the second day back to school after spring break, but did not elaborate. She expressed that she felt the brain games had helped a bit with his focus and memory, and she intended for him to resume playing them. At the end of the questionnaire, she added, “I am really happy that we decided to participate in this study. ADHD is
an extremely difficult thing to live/deal with, so we are very interested in finding other solutions to help us succeed. Thank you for this opportunity.”

**Researcher observations.** Eli was brought to all three sessions by his mother. During the pre-treatment session, he presented as a wide-eyed and curious, but slightly shy, child. He was very polite in his interactions with the researcher. Throughout the session, Eli appeared interested, involved, and as if he was enjoying himself, which are all signs of engagement. There were no observable signs of disaffection.

During the post-treatment session, Eli was very quiet, and kept yawning. He showed effort, concentration, and involvement, which are all signs of engagement. His distractibility was the only evidence of disaffection.

During the follow-up session, Eli was very fidgety, continuously trying to play with the researcher’s computer, and asking questions unrelated to the study. He shared that his mother had taken him off his medication for an upcoming appointment with a new psychiatrist. Throughout the session, he appeared disinterested, distracted, and mentally disengaged. He also gave up on the Brain Age task of completing 100 basic math facts. He said that he was thinking, but was actually just sitting there coloring in the touch screen. All of these behaviors are signs of disaffection. Involvement was the only indicator of engagement during the session. A discussion of Eli’s story can be found in Chapter Five.

**“Fynn.”** This participant was an African American, 17 year-old male, who attended a public high school. His younger sibling Galen, with whom he shared both biological parents, was also a participant in this study. On the parent pre-treatment
questionnaire, his mother stated that she started noticing his lack of attention, lack of focus, and inability to reiterate detailed information when Fynn was six years old. However, since he always maintained good grades, and had no behavior issues, they did not talk to a healthcare professional about these behaviors until 10 years later when his younger brother, Galen, was diagnosed. At the age of 16, Fynn was diagnosed with primarily inattentive type ADHD. His mother stated that Fynn has had some success with medication. Her main concern was that his inability to focus would affect his safety or the safety of others. She gave driving as an example of her concern. Her hopes when enrolling him in this study were that the use of brain games would increase his ability to focus and pay attention to detail.

Through his responses to the participant pre-session questionnaire, Fynn revealed the following information. At the time of the study, he had just started back taking the prescription stimulant Concerta (54 mg). He shared that he felt his medication affected his ability to play football, so he quit taking it during football season, and started taking it again when the season ended. He indicated that he played video games approximately three days per week for about four hours each day. He usually played action, adventure, and sports games. He stated that he did not regularly consume caffeine, and had never been a smoker. He had never suffered memory or speech loss due to a head injury, and did not engage in any sort of daily meditation or relaxation. He considered himself to be somewhere between moderately and highly active.

**SARAC.** Fynn scored 45/80 on the pre-treatment SARAC. His responses indicated that he did not work as hard as he could, or try very hard to do well in
school. It appeared his greatest difficulty was that his mind wandered, and he thought about other things. He indicated that he paid attention in class to some extent, and participated in class discussions, but was uninterested in class most of the time.

On the post-treatment SARAC, Fynn scored 51/80, which was 6 points higher than on the pre-treatment SARAC. His responses indicated that he was working harder, listening more carefully, and feeling better in class than he did prior to playing the games.

Fynn scored 47/80 on the follow-up SARAC, which was 4 points lower than on the post-treatment SARAC. Based on his responses, he was not working as hard or listening as carefully as he was during the treatment period. He also indicated that he was having a little more fun in class.

As seen in Table 31, indicators of disaffection tend to be more prevalent than any of the other factors affecting his overall engagement level.

Table 31

*Disaggregation of Fynn’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores*

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>13</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>25</td>
<td>27</td>
<td>24</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

*TSARAC.* Fynn’s mother asked that he not be required to give the teacher SARAC forms to his teachers. She explained that they had not yet told the school
about his somewhat recent diagnosis of ADHD. He did not want to be treated differently by his teachers because of the diagnosis. For this reason, there were no teacher SARAC reports for this participant.

**FAB.** On the pre-treatment FAB, Fynn scored 17/18. As did many of the other participants, he answered the furniture part of prompt #1 incorrectly, by responding that a table and chair were alike because they had legs. One point was deducted for this error.

Fynn scored 17/18 on the post-treatment FAB, which was the same as on the pre-treatment administration. One point was deducted from prompt #1, as it was on the pre-treatment SARAC, for failing to classify a table and chair as furniture.

**EEG and video/reading questions.** During the post-treatment session, Fynn’s theta/beta ratios showed a decrease for three of the four VQ/RQ activities. As seen in Table 32, his mean theta/beta ratio was also lower during the post-treatment session. From post-treatment to follow-up, there was a ratio increase for two of the activities, and a ratio decrease for the other two.

Table 32

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>5.93</td>
<td>5.03</td>
<td>3.67</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>6.31</td>
<td>3.04</td>
<td>4.04</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>6.05</td>
<td>5.64</td>
<td>6.27</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>6.00</td>
<td>6.02</td>
<td>4.21</td>
</tr>
<tr>
<td>Mean</td>
<td>6.07</td>
<td>4.93</td>
<td>4.55</td>
</tr>
</tbody>
</table>
Fynn scored 9/20 on the pre-treatment VQ/RQ. His score on the post-treatment administration increased by 10 points, to 19/20. On the follow-up VQ/RQ, his score decreased to 14/20.

**Fynn’s scores over time.** Figure 18 represents the change in percentage of possible points scored for the SARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Fynn’s FAB, VQ/RQ, and SARAC all increased from pre-treatment to post-treatment, while his theta/beta ratio decreased. At the follow-up session, his VQ/RQ and SARAC scores decreased, and his theta/beta ratio continued to decrease as well.

![Fynn's Percentage of Change](image)

*Figure 18. Fynn’s percentage of change on the quantitative instruments across sessions.*
**Participant journal and NDSBA.** Fynn’s journal included journal entries for all 25 days during the treatment period, as well as all 10 days during the post treatment period. The entries also included a reasonable amount of detail. He reported that he played for 20 minutes on 15 of the treatment days, 15 minutes on three of the days, and 10 minutes on four of them. Data from the NDSBA verified that he had played on the 22 days on which he reported he had. He also, as suggested, alternated the games that he played during each session. Using the NDSBA data, it was determined that he played an average of 5.2 games per session, which supports the playing times recorded in his journal. These factors increased the trustworthiness of his journal entries. Additionally, the entries appeared to be honest, as Fynn did not seem to hide any negative feelings or behaviors.

Within the treatment period journal entries, there did not appear to be any trends or patterns. Comments expressing engagement, disaffection, and neutrality were evenly and randomly dispersed. On March 3, he reported, “When I was able to do something right, it encouraged me, and when I couldn’t do something I would attempt it, and if I couldn’t get it, it would discourage me.” This appeared to be a theme throughout his journal entries. He was inclined to get dispirited and give up easily if he did not understand something right away. Fynn also seemed as though he was generally not fond of school, finding it boring, and tending to be distracted much of the time.

As of March 4, he started reporting that he “forgot” his medication. On March 8 he indicated that he forgot his medicine, but it did not affect him, and he was able to focus. Again, on March 9, he reported that he forgot his medicine, and added that
it did not affect him as much as it would have before he started playing the brain games. From that point forward, he just wrote “no medicine” each day, instead of stating he forgot it. Although there did not seem to be a pattern within the treatment period journal entries, there did appear to be a change when he stopped playing the games; the positive comments were much more sparse. On approximately 56% of the days during the treatment period, Fynn made at least one positive comment regarding his feelings or behavior during school that day. The presence of positive comments decreased to 20% of the days during the time he was no longer playing the games.

**Participant interviews.** During the post-treatment interview, Fynn indicated that he remembered to play the brain games on his own each morning, and played away from distraction. He stated that he put effort into the games, and tried to increase his scores. He explained that, because he had to wake up early to play the game, it sometimes felt like a chore, but he knew he had to do it because it was helping him. He described the games as being “like a magic pill.” He said he saw the difference they were making through his improvement on his calculus tests. Prior to playing the games, he would be well prepared for a test, but would make careless mistakes when he answered the questions, even when he had taken his medication. On the first test he took, playing the games and taking his medication, he scored a 97. For the next test, he forgot his medication, but still played the games, and scored an 81. He added that the material on that particular test was hard, and most of the people that usually performed well on tests, only received average scores on it. On the next test, he scored a 94. He stated that he was “positive it’s the games,” because
he was doing the same amount of studying he did for the first two tests of the semester on which he got a 78 and 79. In general, he expressed that playing the games increased his focus, and gave him more confidence so he could eliminate careless mistakes. He predicted that during the following three weeks, when he would not be playing the games, he would see the most difference in his test scores.

During the follow-up interview, Fynn confirmed that he had not played any sort of brain game during the previous three weeks. He indicated that, since he returned to school after spring break, he could tell a difference because he was bored and having a hard time focusing. There had been no tests in calculus since he had stopped playing the games, so he did not yet know how that would be affected. He stated that he thought the games helped “fine tune” his focus. He added, “the medication takes care of the big picture, and the games take care of the details.” The researcher asked about the fact that he had not been taking his ADHD medication. He explained that he had stopped taking it because he had started taking an energy supplement as part of his fitness regimen, and knew that they should not be taken together. He indicated that he would resume the use of the games, particularly when he feels like the medication is not enough alone.

Parent questionnaires. On the parent post-treatment questionnaire, his mother verified that Fynn had played the games as requested, and remembered to do it on his own. She stated that, after two weeks of treatment, he seemed to “exude more confidence” and was starting to see positive results. After two to three weeks of treatment, he told her that he felt the games were helping him stay focused in class. She believed that, “At the very least, the brain games help to establish a
regimen and help him to have discipline.” She also felt that the brain games could have been the “catalyst that helped in his success.” At the time of the post-treatment session, she planned for Fynn to resume using the games at the end of the study, and noted that she wanted to start using them too.

Prior to the follow-up session, Fynn’s mother emailed the researcher and stated that, “He is grousing about not being able to play brain games, and is totally looking forward to the study being over so that he can resume his pattern of study.” On the parent follow-up questionnaire, she stated that immediately after spring break, she noticed that he did not seem to be as studious and organized as when he was regularly playing the games. Additionally, she noted that his grades had not gone up anymore since he stopped playing, and he seemed to have “lost his drive.” She indicated that she hoped he would continue to use the brain games as a way to “jumpstart his academic activities,” and shared that she had never seen him more enthusiastic about any other learning process. She said he was convinced that playing brain games was a useful routine for him.

Approximately four months after the follow-up lab session, the researcher received an email from Fynn’s mother explaining that several weeks after the study, she had driven Fynn to Atlanta to take the ACT college entrance exam. She shared that, “Before we left the house, he grabbed his DS and asked for silence in the car as we drove. I looked over at him and he was playing brain games to prep for the exam. I don’t know how frequently he plays brain games, but I know that he does it for the important things! He actually got an 11 out of 12 on the writing section (an area he struggles with). He was very surprised that he did so well.”
**Researcher observations.** Fynn, along with his brother, was brought to all three lab sessions by his mother. During the pre-treatment session, he presented as a very mature and polite young man. Throughout the session, he was quiet and focused. He was involved throughout the session, which was an indicator of engagement. However, he appeared mentally disengaged at times, answering only 9 of the 20 VQ and RQ questions correctly, which was a sign of disaffection.

During the post-treatment session, Fynn demonstrated more signs of engagement than disaffection. Although he appeared bored at times, he displayed satisfaction, effort, concentration, and involvement throughout the session.

Fynn appeared to be equally engaged and disaffected during the follow-up session. He was involved and put forth effort, but he appeared bored, and was mentally disengaged, as was evidenced by the number of questions he missed on the RQ. A discussion of Fynn’s story can be found in Chapter Five.

“Galen.” This participant was an African American, 10 year-old male, who attended a public elementary school. As mentioned in the previous section, Galen’s older brother was also a participant in the study. His mother stated on the parent pre-treatment questionnaire that signs of ADHD started to appear when he was seven. Teachers were commenting on his lack of attention to detail and inability to focus, while his grades started to slip at school. Almost two years later they spoke to a healthcare professional about the difficulty he was having, and he was diagnosed with primarily inattentive type ADHD. At that time, they tried medication, but there was no improvement, and it only made matters worse. Galen’s mother was concerned that he would not be successful in school if they did not find a remedy. By
participating in this study, she hoped he could improve his ability to focus and pay attention to detail.

Galen’s responses on the participant pre-session questionnaire revealed the following information. At the time of the study, he was not taking any medication to treat his ADHD symptoms. He indicated that he played video games approximately three days per week, for two or more hours each day. He preferred action, adventure, sports, role-play, and simulation games. He stated that he did not regularly consume caffeine, and had never been a smoker. He indicated that he had never suffered from memory or speech loss due to a head injury, and did not engage in any sort of daily meditation or relaxation. He considered himself to be only mildly active.

**SARAC.** Galen scored 58/80 on the pre-treatment SARAC. Based on his responses, he believed he worked hard in class, but did not participate in class discussions. He had some responses that appeared to be conflicting. For instance, he answered “very true” that his mind wandered in class, but “not at all true” that he thought about other things. Perhaps this meant he zoned out, and was more “in space” than thinking about something in particular. Another contradiction seemed to be his response of “not at all true” that class was fun, but “very true” that he enjoyed learning new things in class.

On the post-treatment SARAC, Galen’s score increased by 8 points, to 66/80. Based on his responses, which still seemed a little conflicting in nature, he was working harder and having more fun in class than he was before he started playing the games.
Galen’s follow-up SARAC score was 70/80, which was 4 points higher than on the post-treatment SARAC. Overall, his responses indicated that he was working harder and feeling better in class. There was one conflicting response. He replied “very true” that he did not try very hard in school. However, since all of his other responses indicated that he believed he was trying hard in school, it is probable that he misread that particular prompt.

As seen in Table 33, all four factors are similar in their effect on his overall engagement level. However, from pre-treatment to post-treatment, he saw the greatest increase in his behavioral and emotional engagement.

Table 33

Disaggregation of Galen’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th></th>
<th></th>
<th>Disaffection</th>
<th></th>
<th></th>
<th>TOTAL (80)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td></td>
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<td>Emotional (20)</td>
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<td>16</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td></td>
<td>26</td>
<td>33</td>
<td>35</td>
<td>32</td>
<td>33</td>
<td>35</td>
<td>58</td>
<td>66</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Since Galen was in elementary school, he only had two academic teachers. Both of them turned in a pre-treatment TSARAC on his behalf. The average of their scores was 48/80. They were in agreement that he did not listen carefully or pay attention in class. He came to class unprepared, and never did more than was required. Additionally, he seemed to feel good, and did not appear to be angry or anxious in either class.
His teachers’ average on the post-treatment TSARAC was 49/80, 1 point higher than on the pre-treatment version. In general, they reported that his behaviors did not change during the treatment period.

On the follow-up TSARAC, the average was 55/80, which was 6 points higher than on the post-treatment TSARAC. Based on the teachers’ responses, he was more prepared in class, seemed to feel better, and appeared to be more involved.

Based on the disaggregation of Galen’s TSARAC scores, shown in Table 34, the biggest improvement over the course of the study was in his emotional engagement and emotional disaffection during the follow-up period.

Table 34

Disaggregation of Galen’s Pre-treatment, Post-treatment, and 3-Week Follow-up TSARAC Scores

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Post 3-w</td>
<td>Pre Post 3-w</td>
<td>Pre Post 3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>8 8 8 7 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>10 10 12 23 25 28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>18 18 20 30 31 35</td>
<td>48 49 55</td>
<td></td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of point possible for that sub-category.

**FAB.** On the pre-treatment FAB, Galen scored 15/18. One point was deducted from prompt #1 because he responded that a table and chair were used to eat, rather than categorizing them as furniture. One point was also deducted from both prompt #2 and prompt #4.

On the post-treatment FAB, Galen scored 16/18, which was 1 point higher than on the pre-treatment FAB. One point was deducted from prompt #1 because he responded that a table and chair were alike since they were both plastic, rather than categorizing them as furniture. One point was also deducted from prompt #4.
**EEG and video/reading questions.** As can be seen in Table 35, Galen’s theta/beta ratios went up for all four activities from the pre-treatment to the post-treatment session, and again at the follow-up session.

Table 35

Galen’s Theta/Beta Ratios

<table>
<thead>
<tr>
<th>Activity</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>3.71</td>
<td>4.09</td>
<td>6.86</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>3.92</td>
<td>4.45</td>
<td>5.84</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>3.72</td>
<td>3.83</td>
<td>6.06</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>3.46</td>
<td>5.65</td>
<td>6.05</td>
</tr>
<tr>
<td>Mean</td>
<td>3.70</td>
<td>4.51</td>
<td>6.20</td>
</tr>
</tbody>
</table>

Galen scored 11/20 on the pre-treatment VQ/RQ. His scored increased to 16/20 on the post-treatment administration. On the follow-up VQ/RQ, his score increased 1 more point to 17/20.

**Galen’s scores over time.** Figure 19 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Even though Galen’s theta/beta ratio increased from pre-treatment to post-treatment, his FAB, SARAC, and VQ/RQ scores did as well. At the follow-up session, all of his scores increased, including his theta/beta ratio.

**Participant journal and NDSBA.** Galen’s journal contained entries for the entire treatment period, with the exception of March 8, and three days on which he was on a class trip. His mother called the researcher prior to the class trip to make sure it was okay if he did not play during those three days, since the school did not
want them bringing toys or electronic devices on the trip. That was just one indicator of how seriously this family took the study. He indicated that he played for 20 minutes each day. Data retrieved from his NDSBA verified the dates that he played, and showed that he played an average of 3.7 games each session, making it possible that he did play for 20 minutes, or close to it, each time. The variety of games played could have been better, with two of the games not having been played at all, and the remaining seven having been played from 1 to 15 times each. His responses to the journal prompts were only one or two words, with the exception of the entry for February 28. For that first entry, he stated that he felt more focused than normal, but had trouble staying on task for long periods of time, especially in...
writing. He added to that entry that his least favorite class was at the “worst time of day.” All other entries during the treatment period indicated that he experienced average or better feelings and behaviors each day, with no negative references to his feelings or behavior at school. Galen also wrote a journal entry for all 10 days during the post-treatment period. He reported on eight of those days that he felt “ok,” and “not as good” and “bad” on the other two days. He reported that his post-treatment behaviors were a mixture of “good” and “ok.” With the limited detail that was provided within the entries, it was difficult to find a meaningful trend. It is worth stating, however, that the only negative feelings reported were on the first day of treatment, and two of the post-treatment days.

**Participant interviews.** Galen indicated, during the post-treatment interview, that he played the brain games every day, but had to be reminded sometimes. He stated that he played away from distractions, and tried to play at least three games every day. He expressed that he tried to do well, and seemed proud that he had improved his speed on the activities. Although he enjoyed playing the games for a while, he felt it had started to get a little boring. He explained that he felt as though it helped him, because he was paying better attention in math, and not zoning out as much. He expected that he might see a difference during the weeks he would not be playing the games, but added that maybe he would not see a difference since he, in return, would be getting to sleep later in the morning.

Galen’s responses to the follow-up interview questions were very brief. He stated that he had not played any brain games during the three weeks since the post-treatment session. He indicated that, on the first day of school following spring
break, he could tell a difference, finding himself zoning out more. Additionally, he said he was not paying as much attention in class. In his opinion, the brain games “made a big difference,” and helped him stay more focused. He stated that “maybe” he would resume the use of the brain games.

**Parent questionnaires.** On the parent post-treatment questionnaire, his mother verified that he had been playing his game in the mornings, and usually remembered on his own. She indicated that, as far as attitude and behavior, she had not really noticed a difference. However, after three weeks of treatment, he started doing better in school. His mother stated that, “his grades in three subjects increased by one letter grade.” She explained that although the brain games did not seem to change his ADHD behaviors, she feels that they helped with his school performance. She indicated that she planned for him continue using the games after the completion of the study.

On the parent follow-up questionnaire, his mother indicated that she had “seen a decrease in his organization and school performance” since stopping the games. She noticed the difference immediately after spring break. She stated that she had also noticed a drop in his grades since returning from spring break. She expressed that she believed he truly benefited from playing the games, and intended for him to resume playing them.

**Researcher observations.** Galen, along with his brother, was brought to all three sessions by his mother. During the pre-treatment session, he presented as a sweet, polite child, who was highly distracted. During the session, he was laying his head on the table, looking around the room, and when given the Nintendo DS, he did
not wait for or listen to instructions. It was difficult to read his mood because his facial expression never really changed throughout the session. He displayed concentration and involvement, which are signs of engagement, but was also distracted, indicating possible disaffection.

During the post-treatment session, Galen put forth effort and remained involved, which are indicators of engagement. There were no signs of disaffection. Since he was fairly quiet, it was sometimes hard to read his emotions. However, he did smile from time to time.

During the follow-up session, Galen did not display any signs of disaffection, but showed effort, concentration, and involvement, which are all indicators of engagement. He also exhibited pride in having completed the study, and asked if there was going to be a “ceremony” in which he would get his Nintendo DS back. A discussion of Galen’s story can be found in Chapter Five.

“Hayden.” This participant was a Caucasian, 16 year-old male, who attended a private Christian school. His mother indicated on the parent pre-treatment questionnaire that she never noticed any signs of ADHD. She explained that there was a pattern of declining grades, and a learning specialist suggested having him tested. He was diagnosed with combined type ADHD at the age of 16, with his inattentive behaviors being more prominent than his hyperactivity. Hayden’s mom stated that, at the time of the study, they had not yet tried any particular methods to help with the ADHD symptoms. He was going to various tutors, and trying suggested learning strategies, but his parents were not ready to try medication at that time. His mom stated that she was not sure what their concerns were, adding, “This is all
very new to us.” She hoped that playing the brain games would stimulate the less active parts of Hayden’s brain, giving him a viable alternative to medication. Additionally, she hoped that it would improve his learning capabilities and concentration.

Through his responses on the participant pre-session questionnaire, Hayden revealed the following information. As stated previously, he had never taken medication for ADHD. He indicated that he played video games every day for approximately 45 minutes, and longer on the weekends. He preferred action, adventure, and sports games. He indicated that he did not regularly consume caffeine, and had never been a smoker. He had never suffered memory or speech loss from a head injury, and did not engage in any sort of daily meditation or relaxation. As a tennis player, he considered himself to be somewhere between moderately and highly active.

**SARAC.** On the pre-treatment SARAC, Hayden scored 54/80. His responses indicated that he tried fairly hard in school, but at times just acted like he was working, and did not consider school fun. He also replied “very true” that his mind wandered, and “sort of true” that he thought about other things in class.

Hayden scored 51/80 on the post-treatment SARAC, which was 3 points lower than on the pre-treatment administration. His responses indicated that he just acted like he was working in class and did not participate in class discussions.

On the follow-up SARAC, Hayden scored 53/80, which was 2 points higher than on the post-treatment SARAC. His responses went up and down just enough to convey basically the same feelings and behaviors as on the previous administration.
The disaggregation of his SARAC scores, as can be seen in Table 36, indicated that his behavioral engagement is a little stronger than the other three factors.

Table 36

Disaggregation of Hayden’s Pre-treatment, Post-treatment, and 3-Week Follow-up SARAC Scores

<table>
<thead>
<tr>
<th>SARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre  Post  3-w</td>
<td>Pre  Post  3-w</td>
<td>Pre  Post  3-w</td>
</tr>
<tr>
<td>Behavioral (20)</td>
<td>16  14  15</td>
<td>12  12  11</td>
<td></td>
</tr>
<tr>
<td>Emotional (20)</td>
<td>12  14  13</td>
<td>14  13  13</td>
<td></td>
</tr>
<tr>
<td>Engagement &amp; Disaffection (40)</td>
<td>28  26  29</td>
<td>26  25  24</td>
<td>54  51  53</td>
</tr>
</tbody>
</table>

Note. Numbers in parentheses are the number of points possible for that sub-category.

**TSARAC.** Three teachers submitted TSARAC reports on Hayden’s behalf. The average of their scores was 57/80. They were in general agreement that Hayden thought about other things, and was not very enthusiastic about being in class. His geometry teacher indicated that he listened more carefully, seemed more interested, and worked harder in class than his literature and history teachers indicated.

The average of the post-treatment TSARAC was 60/80, which was 3 points higher than on the pre-treatment administration. Based on the teachers’ responses, Hayden did not seem as anxious in geometry and history class. However, his level of frustration appeared to have gone up in geometry, while going down in history and literature. All three teachers were in general agreement that it was “sort of true” that he worked as hard as he could, and it was “not very true” that he did just enough to get by.

On the follow-up TSARAC, his teachers’ average was 59/80. As with Hayden’s self-report, it did not appear that much had changed since they completed the post-
treatment SARAC. His geometry and literature teacher seemed to agree that he was not listening quite as carefully, or working quite as hard, but overall, things were pretty much the same. Table 37 shows the disaggregation of Hayden’s TSARAC scores.

Table 37

**Disaggregation of Hayden’s Pre-treatment, Post-treatment, and 3-Week Follow-up TSARAC Scores**

<table>
<thead>
<tr>
<th>TSARAC</th>
<th>Engagement</th>
<th>Disaffection</th>
<th>TOTAL (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>3-w</td>
</tr>
<tr>
<td>Behavioral (16)</td>
<td>10</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Emotional (En-16, D-32)</td>
<td>11</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Totals (En-32, D-48)</td>
<td>21</td>
<td>21</td>
<td>19</td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses are the number of point possible for that sub-category.

**FAB.** Hayden scored 18/18 on the pre-treatment FAB. Throughout the battery, he stared at the table, which appeared to be his tactic to maintain focus. He was the only participant to receive a perfect score on the pre-treatment FAB.

On the post-treatment FAB, he again scored 18/18. The only noticeable difference was that he listed five more words for prompt #2 than he did on the pre-treatment administration.

**EEG and video/reading questions.** As indicated in Table 38, the post-treatment EEG showed that Hayden’s theta/beta ratio had decreased for three of the VQ/RQ activities. His mean ratio was less than half of what it had been during the pre-treatment session. The ratios for the three activities, which had a decreased ratio during the post-treatment session, increased during the follow-up session. Hayden scored 13/20 on the pre-treatment VQ/RQ. His score decreased by 2 points during the post-treatment session. On the follow-up VQ/RQ he scored 15/20.
Table 38

*Hayden’s Theta/Beta Ratios*

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-wk Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading – no distraction</td>
<td>13.34</td>
<td>6.64</td>
<td>9.88</td>
</tr>
<tr>
<td>Reading with distraction</td>
<td>15.09</td>
<td>5.12</td>
<td>7.21</td>
</tr>
<tr>
<td>Video – no distraction</td>
<td>8.96</td>
<td>8.99</td>
<td>7.21</td>
</tr>
<tr>
<td>Video with distraction</td>
<td>25.64</td>
<td>8.84</td>
<td>11.22</td>
</tr>
<tr>
<td>Mean</td>
<td>15.76</td>
<td>7.40</td>
<td>8.88</td>
</tr>
</tbody>
</table>

*Hayden’s scores over time.* Figure 20 represents the change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The changes in mean post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Hayden’s theta/beta ratio decreased.

![Hayden’s Percentage of Change](image)

*Figure 20.* Hayden’s percentage of change on the quantitative instruments across sessions.
greatly from pre-treatment to post-treatment. Unfortunately, his SARAC and VQ/RQ scores decreased as well. Although there was not much change in his SARAC and TSARAC scores from post-treatment to follow-up, his theta/beta ratio increased, as did his VQ/RQ score.

**Participant journal and NDSBA.** During the post-treatment interview, Hayden claimed that he “pretty much” remembered to write in his journal each day. However, he did not bring any journal entries to the session, and they were not submitted at the follow-up session either. After several attempts to retrieve the flash drive from him, and his mother, it was understood that there would be no journal entries to analyze for Hayden.

The data retrieved from Hayden’s NDSBA indicated that he had played on 14 of the 25 assigned treatment days. The average number of games played per session was 2.6, which means that it is highly unlikely that he played for 15 minutes each session, and even less likely that he played for 20 minutes. Three of the nine games he did not play at all. He played the calculation x20 game 16 times, and five other games from 4–7 times each.

**Participant interviews.** During the post-treatment interview, Hayden indicated that he usually remembered to play the games, but did not play during week five because it was not a “normal” school week. He stated that since he had a lengthy ride to his private school in the mornings, he played in the car on the way to school, and wore the provided earbuds to minimize distraction. He claimed to have put effort into the activities, but added that although they were not difficult, they were not enjoyable either. He indicated that, when he played the brain games, he felt
a little more “awake” throughout the day, adding that he used to sleep on the way to school. He shared that his grades had improved, but that it could have been because he was trying to earn an iPad from his parents. He predicted that, during the three weeks when he would not be playing the games, he would probably be “more tired and less awake.”

Hayden stated, at the follow-up interview, that he had not played any brain games since his post-treatment session. He said that, as soon as he returned to school after spring break, he noticed that he was more tired, distracted, and fidgety than when he was playing the games. He stated that he thought the brain games were what made the difference. He indicated that he would resume playing the games for 20 minutes in the mornings when he could work it into his schedule.

**Parent questionnaires.** On the parent post-treatment questionnaire, his mother stated that Hayden started out being diligent about playing the games, but as his school assignments intensified, and the number of late nights of studying increased, he broke his routine. She indicated that from the beginning, he was very enthusiastic about the games, and wanted to improve his scores. She said he seemed encouraged that playing the games might improve his focus. She felt his attitude toward school was very positive and he worked extremely hard. After about a week of treatment, she noticed a change in his school performance, specifying that, “This quarter he brought his grades up to A’s and B’s – so (his school performance) DEFINITELY improved.” She stated that she thinks the games helped him, and increasing the number of days he played would help even more. She indicated that she intended for him to continue playing them when the study was over. She added
that she felt because of his learning challenges, he was not as diligent in writing in his journal, as he was playing the games, and reiterated how he had to focus on his homework.

His mother indicated, on the parent follow-up questionnaire, that she noticed a change in his behavior and attitude a couple of days after he returned to school after spring break. She wrote, “He has been less focused, and getting assignments turned in on time has been a challenge. He also has had some declining grades.” She said she felt the games were helpful, and she planned for him to resume the use of the games. Additionally, she stated:

I think the games are beneficial. Our society has gotten so dependent on Rx that I think alternatives are really needed. The brain games were good for Hayden. They seemed to help him with focus. The scoring and daily calendar were motivating factors to help him beat his previous score and keep track of his playing. I just wonder if they have to be played 1st thing in the AM to be helpful. I know he did them in the AM, but also in study hall (11 AM) as well. Also, I think some of the basic math skills were good for him to review. He lacks a little self-discipline, but I think as he sees improvements, and realizes them, he will be more consistent. Thank you for letting us participate!

**Researcher observations.** Hayden was brought to each of the lab sessions by his mother. During the pre-treatment session he presented as a very well behaved and polite young man, who remained focused throughout the session. He was a bit fidgety, bounced his knee, and had a bit of a nervous laugh. Having shown interest,
vitality, and involvement, he seemed to be engaged, with no visible sign of disaffection.

During the post-treatment session, Hayden appeared to be engaged, having shown vitality, effort, and involvement. There were no visible signs of disaffection.

Hayden’s follow-up session took place on his birthday. Therefore, it is understandable why he seemed a bit disinterested, indicating some disaffection. However, he still displayed concentration and involvement, which are indicative of engagement. A discussion of Hayden’s story can be found in Chapter Five.

**Summary of Results**

This chapter began with an introduction, reiterating the intent of the study, and reviewing the kinds of data collected to serve this purpose. Descriptive statistics were presented for the five quantitative instruments, and the organization of analyses, based on the research questions, was revealed. Additionally it was explained that the stories of the individual participants would succeed the research question analyses. In this final section of the chapter, results of the data analysis will be summarized.

Results from an ANOVA of the theta/beta ratios, collected to answer the first research question, revealed there was a significant effect of session on mean theta/beta ratio ($F[2,8] = 5.275; p = .035; \eta^2_p = .569$), meaning that the mean theta/beta ratio of the post-treatment session was significantly lower than the pre-treatment and follow-up mean theta/beta ratios. There was also a significant interaction between session and task ($F[6,4] = 10.405; p = .020; \eta^2_p = .940$), meaning that all of the tasks followed the same pattern of decreased mean theta/beta ratio at
the post-treatment session, and increased mean theta/beta ratio at the follow-up session. These data support the literature that accredits brain games with the ability to stimulate the prefrontal cortex of the brain (Crecente, 2006; Kawashima et al., 2005).

Findings from an ANOVA of the SARAC, which was used to help answer the second research question, showed that there was not a significant effect of session on SARAC scores ($F[2,18] = .932, p = .412$), meaning that the increase in the mean scores from pre-treatment to post-treatment was not significant. Analysis of participant journals (see Table 7), used in order to help answer research question two, revealed that six of the nine participants who kept journals showed patterns of increased engagement during the treatment period. During participant interviews, the final piece of data collected to answer the second research question, nine participants indicated that they had noticed a positive difference in their ability to focus, pay attention, concentrate, or engage in class during the treatment period.

Results from an ANOVA of the TSARAC, which was used to answer research question three, showed that there was not a significant effect of session on TSARAC scores ($F[2,18] = .965, p = .40$), meaning that there was not a significant increase in scores from pre-treatment to post-treatment, or a significant decrease in scores from post-treatment to follow-up.

Analysis of the parent questionnaires (see Table 8), which were used to answer the fourth research question, revealed that 9 out of 10 parents saw an improvement in one or more symptoms of their child’s ADHD during the treatment period. Additionally, on the follow-up questionnaire, 8 out of 10 parents revealed
that they had seen a negative change in one or more of their child’s symptoms of ADHD since they had stopped treatment.

Findings from the researcher observations, which were collected to answer research question five, revealed four of the participants showed a large increase in engagement level, from pre-treatment to post-treatment, and three other participants showed a smaller increase. Additionally, no change was reported for two of the participants, and a negative change was observed in one.

A paired sample t-Test of the FAB, which was used to help answer the sixth research question, revealed that there was a significant increase from the pre-treatment FAB ($M = 14.80, SD = 2.936$) to post-treatment FAB ($M = 16.40, SD = 2.011$), $t(9) = -2.516, p = .033$), with a medium to large effect size ($d = .67$). An ANOVA of VQ/RQ scores was also used to help answer research question six, revealing that there was a significant effect of session on VQ/RQ ($F[2, 18] = 8.12; p = .003; \eta^2_p = .474$). A pairwise comparison with Bonferroni correction showed that the significant difference was between the scores for the pre-treatment and follow-up sessions ($p = .02$). These data support the literature that claims the benefit derived from decreased theta and increased beta can transfer to the daily use of executive functions (Kropotov et al., 2007).

Figure 21 represents the mean change in percentage of possible points scored for the SARAC, TSARAC, FAB, and VQ/RQ. The mean changes in post-treatment and follow-up theta/beta ratios are also presented as percentages of the mean pre-treatment ratio. Note how, at the post-treatment session, the mean theta/beta ratio dropped to 74% of what it had been at the pre-treatment session,
and then returned to within 1% of its origin during the follow-up session. Means for all four of the remaining quantitative instruments increased from pre-treatment to post-treatment, but in varying degrees. At the follow-up session, the SARAC and TSARAC means decreased, approaching their pre-treatment means, while the VQ/RQ mean sustained a slight additional increase.

What do these findings suggest? How do these results support or contradict the years of research leading up to this study? Chapter 5 answers these questions, provides implications for the fields of education and psychology, and offers suggestions for future studies in this area.

Figure 21. Mean percentage of change on the quantitative instruments across sessions.
Chapter 5: Discussion

Introduction

In the previous chapter, the results of the data collection and analysis were reported. This chapter consists of a summary of the study, discussion of the findings, implications for practice, recommendations for future research, and conclusions. The purpose of the latter sections is to provide guidance to those who seek an alternative to medication for the treatment of ADHD and those who wish to continue adding to the body of research in this area. The conclusion of this chapter will attempt to synthesize the whole of this journey into a final statement of justification.

Summary of Study

The purpose of this study was to add to the research on non-pharmaceutical alternatives for the treatment of ADHD. Specifically, it sought to determine if the daily use of brain games such as Nintendo DS Brain Age (NDSBA) could increase the engagement of students with ADHD. It was directed at finding a relationship between the participants’ use of brain games and their level of classroom engagement.

Two frameworks were used as guides throughout this process: the executive dysfunction framework (Johnson et al., 2009), which is based on the premise that the symptoms of ADHD are caused by a reduced level of executive control, and the engagement versus disaffection framework (Skinner & Belmont, 1993), which views
prolonged behavioral participation along with a positive emotional attitude as the definition of engagement.

In order to fulfill the purpose of determining if the daily use of brain games such as NDSBA could increase the engagement of students with ADHD, the following sub-questions were formulated: (1) What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD? (2) What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD? (3) What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD? (4) What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms? (5) What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD? (6) What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?

Ten participants were chosen from a volunteer pool of 5th through 11th grade students with ADHD. A demographic disaggregation by gender, race, age, type of ADHD, and medication status was provided in the Chapter Three section on participants. Participant pseudonyms were assigned to protect participant identity.

Participants were instructed to play NDSBA for at least 20 minutes every morning before school, for a total of five weeks. The treatment was then removed for the week of spring break and two additional weeks of school.

Quantitative and qualitative data were collected to answer the sub-questions of the study. The following data were collected during pre-treatment, post-treatment, and follow-up phases of the study: The Student’s Achievement-Relevant
Brain Games and ADHD

Actions in the Classroom (SARAC) and teacher SARAC (TSARAC) (Skinner et al., 2009), EEG determined theta/beta ratios, video and reading questions (VQ/RQ), parent questionnaires, participant interviews, and researcher observations. A frontal assessment battery (FAB) (Dubois et al., 2000) was administered at the pre-treatment and post-treatment sessions. Additionally, participants kept an electronic journal during the eight-week treatment and follow-up periods, and data from their NDSBA were retrieved.

The SARAC, TSARAC, theta/beta ratios, and VQ/RQ were analyzed using repeated measures ANOVAS. A paired-samples t-Test was used in analysis of the FAB. Finally, a combination of deductive analysis, inductive analysis, and direct interpretation were used to analyze the data from the participant journals, participant interviews, researcher observations, and parent questionnaires.

Discussion of the Findings

There is abundant research supporting the theory that ADHD is caused by dysfunction in the brain’s prefrontal cortex (Barkley, 1997; Brennan & Arnsten, 2008; Dickstein et al., 2006; Dige & Wik, 2005), and a growing number of studies that accredit brain games with the ability to stimulate this area of the brain (Crecente, 2006; Kawashima et al., 2005), which provided a strong scaffold for this study. However, until this study, the research tying these two variables together was remarkably scant and inconclusive. The objective of this study was to determine if the daily use of brain games such as NDSBA could increase the engagement of students with ADHD, thus providing an alternative to medication for its treatment. The remainder of this section will focus on discussion and implications of the
findings for each of the six research questions, as well as a participant-by-participant analysis.

**Research question one: What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD?** The findings related to this research question indicate that session had a significant effect on theta/beta ratio. Additionally, when the mean of the pre-treatment and follow-up theta/beta ratios was contrasted with the post-treatment theta/beta ratio, significance was indicated. In other words, there was a significant decrease in the mean theta/beta ratio from pre-treatment to post-treatment, which supports the hypothesis that post-treatment theta/beta ratios would be significantly lower than the pre-treatment theta/beta ratios.

Although task did not have a significant effect on mean theta/beta ratio, there was a significant interaction between session and task, meaning that the session had an effect on the theta/beta ratio for each task. The ratios for all four activities followed the same pattern, a decrease at post-treatment and an increase at the follow-up, but to different degrees. These data strengthen the value of the results in that they indicate the improvement in theta/beta ratio did not discriminate by task. Furthermore, the mean theta/beta ratio decreased by 2.075 from pre-treatment to post-treatment, and then increased by 1.995 from post-treatment to follow-up, meaning that it had almost returned to the pre-treatment level. This suggests that if there had been any residual effects from the brain game use, they had diminished greatly by the follow-up assessment, and that continued
use of the brain games is most likely necessary for maintaining the benefits of their use.

The EEG results suggest that the use of brain games might have promise as an alternative treatment similar to neurofeedback (CHADD, 2008b), in that it focuses on increasing beta and decreasing theta in patients with ADHD. Unlike neurofeedback, the use of brain games does not require a weekly trip to a clinician, which is not covered by insurance for most patients (2008b). As with neurofeedback, however, some will question whether patients will actually see the change in brain activity transfer to daily use of their executive functions (Kropotov et al., 2007). Research question six of this study sought to help answer that query.

**Research question two: What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD?** One quantitative and two qualitative instruments were used to answer research question number two. Although the SARAC scores increased from pre-treatment to post-treatment, and decreased from post-treatment to follow-up, neither one of these changes was significant. Considering the positive results of the qualitative instruments used for this research question, it is possible that the small sample size was at fault for lack of significance in SARAC scores. It is possible that, if a similar study was conducted with a much larger group of students, a pattern such as this might warrant a finding of significance. However, for this study, the results support the null hypothesis that post-treatment SARAC scores would not be significantly higher than pre-treatment SARAC scores.
It should be kept in mind that ability of students to accurately assess their own thinking and behavior varies (Assor & Connell as cited in Chapman, 2003b), meaning for some of the participants, their results might be less meaningful. Another downfall of the SARAC is that it provides a “snapshot” of the participant’s feelings at one moment in time. If a participant happened to have had an exceptionally good or abnormally bad day at school on the day that they completed the SARAC, it is possible that they could have been influenced to answer differently than they would have on just an average school day. Overall, the engagement versus disaffection framework (Skinner & Belmont, 1993) served as a useful lens through which to view the participants’ emotions and behaviors, in order to help determine their levels of engagement.

Out of the nine participant journals that were completed, six of them showed some sort of pattern or evidence of increased engagement from the pre-treatment to the post-treatment period. These data support the hypothesis that aggregated data from journal entries would show patterns of increased engagement during the treatment period. It should be noted, however, that most of the participants were not as consistent or thorough in their journal entries as the researcher had hoped they would be. As described in Chapter Four, many of the responses were only one to three words in length, which did not allow for a lot of detail to be gleaned. Some of the participants had gaps in their entries where nothing was written at all, leaving holes in the overall picture of the treatment and follow-up periods. With this in mind, it did appear that when they wrote in their journals, the entries were honest. For instance, if they misbehaved, they confessed to their behavior in their journals.
During the post-treatment interviews, seven participants stated that they had noticed a positive difference in their ability to focus, pay attention, concentrate, or engage in class. Various participants also reported feeling more awake, better behaved in class, and/or more successful in math class. It is possible that the games helped students feel more confident in math class since it allowed them to practice their basic math facts and skills on a regular basis. Only one participant stated that he did not notice any difference in his symptoms of ADHD during the treatment period.

During the follow-up interviews, seven participants indicated that, since they had stopped playing the games, they were less focused and having a harder time paying attention in class. Various participants also reported having worse classroom behavior, being more fidgety, feeling more bored, and/or seeing a drop in grades since stopping the treatment. Of particular interest to the researcher was the fact that four participants also indicated they felt they were getting angrier faster and more easily since stopping the games. Although this was not one of the foci of the study, it was fascinating considering that a quick temper is sometimes associated with ADHD (Marcus & Mattiko, 2007). This finding suggests that perhaps the use of brain games can help treat symptoms of ADHD, other than those specified in this study. The same participant that stated he did not notice any differences during the treatment period, was also the only one who stated that he could not tell a difference after stopping the games. Overall, these data supported the hypothesis that aggregated data from participant interviews would show patterns of increased engagement during the treatment period.
Research question three: What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD? Although the mean TSARAC was slightly higher than pre-treatment at post-treatment, and slightly lower than post-treatment at follow-up, a repeated measures ANOVA indicated that the difference in scores was not significant. These results support the null hypothesis that post-treatment TSARAC scores would not be significantly higher than pre-treatment TSARAC scores. The pattern of TSARAC scores was similar to that of the SARAC scores, but to a less prominent degree.

Two unfortunate factors were noted that could have had a negative effect on the results of the TSARAC data. First of all, there was the absence of TSARAC data for Blake and Fynn, which were the two participants who reported the greatest improvement during treatment, and greatest regression during the follow-up period. It is probable, considering the level of success noted by these participants and their parents, that their teachers would have observed a notable improvement as well. Additionally, for several of the remaining participants, there seemed to be a lack of effort, on the part of the teachers, to provide thoughtful responses. The cause of this could have been that the teachers perceived having to complete the TSARAC as an increase to their workload, which is one of the main causes of low teacher morale (Briggs & Richardson, 1992). This is unfortunate considering the importance of teacher involvement in the ADHD treatment process (DuPaul, 2007). As noted earlier, it appeared that one of the teachers had filled out two of the forms at the same time, while a whole group of teachers submitted the same responses on their electronic submissions of the follow-up TSARAC as they had on their post-treatment
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This error could have possibly been prevented if all participants had followed the directions for collecting TSARAC scores as specified by the researcher, which did not include giving teachers more than one copy of the instrument at a time, or allowing electronic submission. It is also possible that after five weeks of treatment, the participants were feeling a difference in their ability to focus, but that it was just not enough time for the improvement to carry over to the classroom.

**Research question four: What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?** The findings related to research question four support the hypothesis that aggregated data from parent questionnaires would show patterns of decreased observance of ADHD symptoms during the treatment period. Seven out of ten parents reported that, during the treatment period, their child had increased his or her grades, or was generally doing better in school. Two more parents, although not specifically referencing school, stated that, during the treatment period, they had seen improvement in either the calmness of their child, or ability to focus and remember things. There is always the possibility that the parents felt obligated to provide some kind of positive results because of the time the researcher had put into this study. However, they were reminded to be honest in their responses. There were clearly two parents that contributed an abundance of detail, and were absolutely convinced that the games had made a huge impact. Whereas the other parents provided less detail about the changes they had seen, but were reasonably sure the games had helped.

As stated in Chapter Four, only one parent indicated that she did not notice any change in her child’s symptoms of ADHD. Her child, John, on the other hand,
indicated that he was more focused and did not fall asleep as much in class during the treatment period. John also stated that, during the follow-up period, he found that he was moving and tapping more, and his grades had dropped. However, his results overall were highly inconsistent. Aside from the information provided in his interviews, only the FAB and VQ/RQ indicated any improvement during the treatment period. It is discussed in the upcoming section about John, that he could be one of the 15% of children with ADHD who actually have excess beta in their frontal lobes (Clarke, Barry, McCarthy, et al., 2002). If this is the case, it is possible that this type of treatment may not be appropriate for him, or if it is, that it could take longer for the benefits to be observed by others.

**Research question five: What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?**

Data analysis directed at answering the fifth research question supports the hypothesis that there would be an increase in observer-reported engagement at the post-treatment lab session as compared to the pre-treatment lab session. The researcher observed a large positive change in four of the participants, and a smaller positive change for three of them. For two of the three participants who showed no signs of disaffection during the pre-treatment session, no change was noticed. There were still no signs of disaffection during the post-treatment session, and there was an equal amount of characteristics of engagement. However, the third participant who exhibited no signs of disaffection during the pre-treatment session, was actually slightly disaffected at the post-treatment session. His mother subsequently informed the researcher that they believed his ADHD medication had stopped working. By the
follow-up session, he had stopped taking his prescription, Intuniv, in preparation for a new medication, and appeared to be much more disaffected, and less engaged.

**Research question six: What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?** Two quantitative instruments were used to help answer research question six. A paired sample t-Test was run on pre-treatment and post-treatment FAB scores, revealing a significant increase from one to the other. These data support the hypothesis that the post-treatment FAB scores would be significantly higher than the pre-treatment FAB scores. It is not likely that a practice effect was the reason for the increase in scores. With five weeks between administrations, and no indication of pre-treatment FAB results having been given to participants, it is probable that this instrument legitimately helped evaluate their levels of executive functioning.

Additionally, a repeated measures ANOVA indicated a significant effect of session on VA/RQ scores, meaning that there was a significant difference between the scores for two or more sessions. A pairwise analysis revealed a significant increase in VQ/RQ scores from pre-treatment to follow-up treatment. These data support the hypothesis that the post-treatment VQ/RQ scores would be significantly higher than the pre-treatment VQ/RQ scores. However, it is possible that participant comfort level had increased during the post-treatment session, since they knew what was expected of them. This could have contributed to their increase in VQ/RQ scores.

As illustrated in Figure X, the follow-up mean was slightly higher than the post-treatment mean. This suggests that there could have still been some residual
effects from the treatment during the follow-up period, or possibly that the brain was still adjusting in some way to the prior use of the games.

Data from the FAB and VQ/RQ suggest that the use of brain games can help improve executive function in those with ADHD. This information speaks to the questions that some have had about forms of treatment that increase beta and decrease theta, and the patient's ability to transfer the changes in wave activity to everyday tasks of executive function (Kropotov et al., 2007). Additionally, it supports the findings of Kawashima and his team, that brain games can help improve executive functions, which can be observed in the improved performance of cognitive tasks (2005).

Summary of Jane. Based on the compilation of data, it is possible that the brain games helped Jane in several ways. First of all, her theta/beta ratios were lower after playing the games for five weeks. This suggests that the frontal lobe of her brain was more alert during the post-treatment EEG than during the pre-treatment EEG. During the pre-treatment EEG session, Jane only scored 12/20 on the VQ/RQ. However, on the post-treatment administration, her total increased to 18/20. A possible explanation for the increase in scores from pre-treatment to post-treatment is the corresponding decrease in theta/beta ratio, and the possibility that this change helped her better focus on the tasks at hand. This improvement, as well as her improvement on the FAB, implies that her executive functioning had improved since the pre-treatment session. This type of finding helps support the questions some have about whether the change of brainwave activity can carry over into a participant's daily executive functioning (Kropotov et al., 2007).
At the post-treatment session, Jane told the researcher that she felt as though the games had helped her focus a little better at school, especially in math class. However, based on the TSARAC, Jane’s math teacher did not see much of a difference between the treatment period and the pre-treatment or follow-up periods. It is possible that Jane was just feeling more confident in math because she had been practicing her basic math skills on NDSBA. Additionally, Jane’s teacher is the only respondent that did not seem to observe any effects of the treatment. Perhaps, if Jane increased the time played, to the recommended amount, there would be a more observable improvement in classroom performance.

At the time of the post-treatment session, Jane had seen some improvement in her ability to manage her symptoms of ADHD. However, it was not until the follow-up period that more specific changes in her behavior were identified. Both Jane and her grandmother felt that her attitude had deteriorated since stopping the games. Jane shared that things were making her angry that did not bother her during the treatment period. This was interesting to the researcher considering that temper and mood are often affected by ADHD (Marcus & Mattiko, 2007). Bearing this in mind, it is possible that stimulating the pre-frontal cortex could treat symptoms of ADHD other than focus and executive functioning.

**Summary of John.** Based on the data collected on John, it is inconclusive as to whether or not he benefited from the use of the brain games. His journal entries and VQ/RQ suggest that he was more able to focus during the treatment period than he was pre-treatment. Additionally, during both his post-treatment and follow-up lab sessions he told the researcher he could tell a difference in his focus when he
was using the games. Conversely, the SARAC, TSARAC, and parent questionnaires indicated that there was not much of a difference in John’s focus between the various phases of the study. Perhaps he did feel a difference, as he reported in his journal and in the interviews, but it just was not enough of a difference to help him successfully regulate his focus during the many distractions at school. He was able to do better on the VQ/RQ, but the lab setting was void of what is often the most critical distraction to a child with ADHD... his classmates. Maybe a duration of use, longer than the five weeks in this study, would allow the strength of any effects to increase so that they were applicable to the classroom setting.

There was one particular trend in John’s data that really interested the researcher. John only scored 8/20 on the VQ/RQ during the pre-treatment EEG session. On the post-treatment administration, his total increased to 17/20. Bear in mind that his theta/beta ratio also increased for all four VQ/RQ activities during the post-treatment session, which, based on theory, would mean that his brain was working less efficiently than during the pre-treatment session. It is possible that, since he knew the researcher was hoping to see an improvement in focus after the treatment period, he consciously tried harder to focus during the post-treatment session than he did during the pre-treatment session. However, considering his level of hyperactivity in the pre-treatment session, perhaps the increased theta/beta ratio helped him focus better by slowing his brain activity down to a more productive level. With this in mind, it seems possible that he could be one of the 15% of children with ADHD who actually have excess beta in their frontal lobes (Clarke, Barry, McCarthy, et al., 2002). When all of this information is taken into account,
along with the fact that he is one of 20% of ADHD patients for whom prescription stimulants are not effective (Fox et al., 2005), it seems feasible that there may be a large overlap between these two subgroups. Is it possible that the reason stimulant medications do not work for a fifth of those with ADHD is because they already have a large amount of beta activity, and therefore do not need any more stimulation in their frontal lobes? Since the theory behind stimulant medications is that they activate neurotransmitters in order to stimulate the prefrontal cortex (Szegedy-Maszak, 2002), and that is what the use of brain games appears to do as well, it would make sense that the brain game treatment did not work for this participant.

**Summary of Aaron.** Based on the sum of data collected for Aaron, it appears as though the games had some effect on his ability to focus. The only data that would seem to suggest otherwise are his responses on the post-treatment SARA. However, that score is representative of how Aaron was feeling about school on the day he completed the questionnaire, and the data did not coincide with the more complete story of improvement provided in his journal.

After playing the brain games for five weeks, Aaron’s theta/beta ratio had decreased for three of the four VQ/RQ activities. This suggests that his frontal lobe was more alert during the post-treatment EEG session than during the pre-treatment EEG session. During the follow-up EEG session, Aaron’s theta/beta ratios increased for all four VQ/RQ activities. Considering these data, it appears that whatever benefit Aaron had obtained from the use of the brain games was no longer present once he stopped playing them. On the pre-treatment VQ/RQ, Aaron scored 12/20. His score increased to 14/20 at post-treatment, and again to 16/20 during
the follow-up session. It is possible that the decrease in theta/beta ratio, recorded during the post-treatment session, helped him focus better while reading and watching the video. Additionally, even though his ratios had increased at the follow-up session, his VQ/RQ score still increased. One explanation is that Aaron could have been making a more conscious effort to do well on the activities to make up for the decrease in focus he had felt since he stopped playing the games.

Though the improvements in his TSARAC, FAB, and VQ/RQ may seem slight, they still served to support the positive pattern realized in Aaron’s journal and EEG results. Since he takes a fairly large dose of Adderall, it is probable that without the medication, baseline measures would have been lower, or higher in the case of theta/beta ratios, allowing more room for improvement.

**Summary of Blake.** Based on data from the FAB, SARAC, and VQ/RQ, it appears as though the use of the brain games helped Blake slightly improve his ability to focus, and engage in class. However, the story Blake and his parents tell suggests a much greater impact. According to his parents’ statements, there was a drastic improvement in his behavior during the second week of use, and a drastic decline in his behavior only two days after ceasing the treatment. His mother specifically stated that he seemed calmer and less agitated during the treatment period. Interestingly, although the study did not focus on the effects of the treatment on mood and temper, Blake was the second participant for which this improvement was brought to the researcher’s attention.

Some interesting observations were made concerning Blake’s EEG and VQ/RQ results. For both VQ/RQ activities with no distraction, Blake’s post-
treatment theta/beta ratios were lower than they had been during the pre-treatment session. However, for both activities with distraction, his ratios increased. A possible explanation is that playing the games was helping increase the activity in his frontal lobe, improving his general focus, but that he was still having difficulty blocking out extraneous stimuli such as the distractions provided by the researcher. Of additional interest was the fact that during the follow-up EEG, Blake’s ratios for all four VQ/RQ activities had increased to levels higher than they were at the pre-treatment session. One possible explanation is that the stopping of the brain games caused a withdrawal effect, and his frontal lobe was still adjusting to the absence of the treatment. The researcher found this supposition to be particularly fascinating considering Blake’s mother had commented that, since his reaction to stopping the games was so extreme, she wondered if it could have caused withdrawal effects similar to those when one stops taking medication.

It is important to keep in mind that Blake was already taking a fairly large dose of Adderall each day, and it is possible that without the help of the medication, an even greater improvement may have been observed from pre-treatment to post-treatment. Aside from the favorable results realized by this participant, his situation added to the study by bringing to light the question about frequency of use. There is reasonable probability that he would realize even greater levels of success if he began playing the games in the morning, and then again before his last two class periods.

**Summary of Caleb.** Based on the compilation of quantitative instruments, it appears that the brain games helped improve Caleb’s focus and engagement during
the treatment period. However, it was not until the follow-up period that Caleb and his mother seemed to realize there had been an improvement. Caleb mentioned that he felt he got angrier faster when not playing the games, and his mother described his behavior during the treatment period as calmer. This made Caleb the third participant for which these sort of claims had surfaced. Perhaps for these participants, part of the explanation can be found within the State Regulation Model of ADHD (Johnson et al., 2009), which states that if information is presented too rapidly for a student’s mental activation state, he or she may become frustrated and give up or lose focus. It is possible that during the treatment period, Caleb maintained a better state of mental activation, and therefore was able to handle information that was presented more rapidly, which limited the feelings of anger and frustration. Once the treatment was removed, it once again became harder for him to field rapidly presented information, causing a rise in moments of frustration and anger. This explanation is also feasible for the other participants who noted feeling more calm during the treatment period.

One concern that is worth noting for Caleb is that although he had a drastic improvement from pre-test to post-test in is FAB, 9/18 to 16/18, and VQ/RQ scores, 7/20 to 15/20, it is difficult to know whether the brain games were responsible, or the fact that he had taken his ADHD medication the morning of the post-treatment session, but not the morning of the pre-treatment session. However, even though he took his medication on the day of the follow-up session, his VQ/RQ score went back down, to 12/20, which suggests that the use of the games were at least partly responsible for the improvement.
**Summary of Dante.** When considering all of the data collected for Dante, it seems possible that the brain game treatment had a positive impact on his ability to focus. This was indicated by slight improvements in the quantitative assessments from pre-treatment to post-treatment, and supported by EEG evidence that his theta/beta ratios had decreased. The fact that he made such improvements on his school performance and behavior rating scale was impressive as well. Additionally, Dante was the fourth participant to volunteer that he got angrier faster after stopping the games, making this perhaps the most interesting of any unexpected findings in this study.

Alone, Dante’s SARAC totals would indicate that he did not see much change in his engagement during the treatment period. However, because of the conflicting responses he provided, on both the pre-treatment and follow-up administrations, the trustworthiness of his SARAC data was compromised.

From pre-treatment to post-treatment, there was a decrease in Dante’s theta/beta ratio for all four VQ/RQ activities. This suggests that during the post-treatment session, his frontal lobe was functioning more efficiently than it had been during the pre-treatment session. Conversely, from post-treatment to follow-up, ratios for all four activities decreased, suggesting that any improvement realized during the treatment period was lost after Dante stopped playing the games.

Dante scored 11/20 on the pre-treatment VQ/RQ. He increased his score by 2 on the post-treatment administration, for a total of 13/20. On the follow-up VQ/RQ, his score again increased by 2 for a total of 15/20. A possible explanation for this trend could be that when his theta/beta ratios decreased, he was better able to
focus on the assigned tasks. Furthermore, regardless of the fact that his ratios had increased at the time of the follow-up session, perhaps some residual effects allowed him to maintain better self-control over his focus.

**Summary of Eli.** If only considering Eli’s theta/beta ratios, one would probably assume that this participant had seen success. However, this was not actually the case. Neither Eli, his teachers, his mother, nor the researcher reported observing an improvement in his focus or engagement. In fact, Eli’s teachers seemed to observe a decrease in his engagement from the pre-treatment to the post-treatment period. It is not likely, however, that the use of the games was the cause of his decreased engagement. It is more probable that something else was negatively affecting his engagement level, and the treatment could not compete with that factor.

Eli noted that even his classmates were commenting on his being off task. As discussed in Chapter Two, off task behaviors such as Eli’s, often cause a negative impact on their social acceptance as they age (CHADD, 2003a). He explained that his classmates often call him back to task in a helpful way. However, his peers’ attitudes about his disruptive conduct will most likely change in the next few years if he does not find an effective treatment for his ADHD symptoms.

On the post-treatment FAB, Eli scored 17/18, which was 1 point higher than on the pre-treatment FAB. One point was deducted from prompt #5, which is a test of inhibitory control. He also lost one point on this prompt the first time he completed the FAB. It makes sense that this prompt was still giving him difficulty,
even after treatment, considering his mother’s comment that he continued to be very impulsive.

Eli’s theta/beta ratio decreased for three of the four VQ/RQ activities, from pre-treatment to post-treatment. Furthermore, his mean theta/beta ratios showed a decrease from pre-treatment to post-treatment, with a small increase at the follow-up, which suggests that his frontal lobe was more alert during the post-treatment session than the pre-treatment session. However, his VQ/RQ scores did not seem to show a carry over of improved brain activity into a school-type task. Eli scored 12/20 on the pre-treatment VQ/RQ, and his score decreased to 8/20 on the post-treatment assessment. On the follow-up assessment, his score increased 2 points to 10/20. It is probable that the behavior exhibited during these activities resembles that which his teachers observe in the classroom. The VQ/RQ questions were in no way too difficult for the participant, so it seems likely that he was thinking about other things, rather than actually watching the video or reading the material.

**Summary of Fynn.** Both the quantitative and qualitative data collected for Fynn support the assumption that the brain games had a positive effect on his ability to focus and engage. Even when he stopped taking his medication, he was able to maintain a level of focus that he had not been able to in the past. Considering that there were no TSARAC scores for Fynn, it was helpful that he and his mother were able to provide details about the treatment and follow-up periods. His maturity seemed to enhance his ability to analyze the effects of the games.

Based on Fynn’s SARAC scores, it appears that he was more engaged during the post-treatment period than pre-treatment. These results also suggest that the
improvement Fynn had noticed during the treatment period, had started to dissipate during the follow-up period. As seen in Table 22, indicators of disaffection tend to be more prevalent than any of the other factors affecting his overall engagement level.

During the post-treatment session, Fynn’s theta/beta ratios showed a decrease for three of the four activities. His mean theta/beta ratio was also lower during the post-treatment session. This suggests that the use of the brain games helped activate his frontal lobe. Fynn’s score pattern on the VQ/RQ activities implies that the activation in his pre-frontal cortex transferred to his ability to complete cognitive tasks. Fynn scored 9/20 on the pre-treatment VQ/RQ. His score on the post-treatment administration increased by 10 points, to 19/20. On the follow-up VQ/RQ, his score decreased to 14/20.

This participant was of great interest to the researcher because of his attitude toward the brain game treatment. Having called the treatment a “magic pill” after five weeks of use, he explained that even though he did not enjoy having to wake up earlier in the morning to play the games, he would continue to do it because of the impact on his school performance. For this reason, it seems that age could be a possible factor in the success of brain games as a treatment. If a patient was too young to understand that the benefits attained should outweigh any negative feelings associated with playing the games, then they would probably be more likely to just go through the motions, without actually putting thought into the games, or just quit altogether.
Summary of Galen. Interestingly, although his theta/beta ratios consistently increased throughout the study, Galen appeared to benefit from the use of the brain games. While there was some improvement noted in his SARAC, FAB, and VQ/RQ, the most telling factor was his mother’s report that his grades went up during the treatment period, and back down when he stopped playing the games.

Galen’s theta/beta ratios increased for all four activities from pre-treatment to post-treatment, and again at the follow-up session. On the other hand, Galen scored 11/20 on the pre-treatment VQ/RQ, and his score increased to 16/20 on the post-treatment administration. On the follow-up VQ/RQ, his score increased 1 more point to 17/20. Contrary to the hypotheses of the study, Galen’s VQ/RQ scores had a positive correlation to his theta/beta ratios, rather than a negative one.

Perhaps Galen is part of the small percentage of children with ADHD who have increased beta levels (Clarke et al., 2001). Additional EEG data was examined for Galen, and his beta levels decreased for all four activities, during both the post-treatment and follow-up sessions. It is possible, if he is part of this unique subset, that increased theta/beta ratios could actually be a positive change for him. Like John, who the researcher also suggested could be a part of the increased beta subgroup, Galen did not respond well to stimulant medication. This fact supports the researcher’s supposition that the subgroup with increased beta, and the subgroup that does not respond to stimulant medication, have a notable overlap.

Summary of Hayden. Based on the data collected on Hayden, it is inconclusive as to what extent his engagement was affected by the treatment. Data from the TSARAC, parent questionnaires, and participant interviews suggested that
Hayden was more engaged and focused during the post-treatment period than he had been pre-treatment. On the other hand, his SARAC scores indicate that he was less engaged in class during the treatment period. Additionally, the researcher did not notice an increase in engagement at the post-treatment session.

Based on Hayden’s post-treatment EEG, which showed that his theta/beta ratio had decreased for three of the activities, one would surmise that the treatment had been successful. His mean ratio was less than half of what it had been during the pre-treatment session. The ratios for the three activities, which had a decreased ratio during the post-treatment session, increased during the follow-up session, suggesting that the use of the brain games supported his frontal lobe in working more efficiently, and the benefit diminished once he stopped playing the games. However, contrary to the hypotheses of this study, his scores on the VQ/RQ activities were positively correlated to his EEG results. Hayden scored 13/20 on the pre-treatment VQ/RQ, and decreased by 2 points, to 11/20, during the post-treatment session. On the follow-up VQ/RQ, he scored 15/20. It is possible that, since he felt the games were “not enjoyable”, he purposely did not do as well on the post-treatment VQ/RQ so that the researcher would not report that the games had helped his focus. He might have feared that a positive report would cause his mother to make him resume playing the games. This could have been the cause of his decreased post-treatment SARAC score as well.

**Implications for Practice**

Treatment for ADHD should follow the same basic guidelines for children, adolescents, and adults; it should be “multifaceted and individualized to meet the
needs of the patient,” (Resnick, 2005). Because of the contrasts between individual cases of ADHD, medical practitioners, parents, and teachers are on an eternal search for treatments that will remedy the symptoms of ADHD.

The findings of this study suggest that the use of brain games, such as NDSBA, could be a possible alternative, or complementary treatment, for ADHD. Specifically, this study focused on how these games affect the theta/beta ratio, and related levels of classroom engagement and executive functioning, of 5th through 11th grade students, with primarily inattentive type or combined type ADHD. The overall results of this study imply that, for the specified population, the use of brain games can decrease theta/beta ratios, which often translates into increased engagement and improved executive functioning.

For parents of children with ADHD, this information suggests an affordable, non-pharmaceutical, alternative to ADHD medication. As with medication, or any other treatment, not every child will see an improvement with the use of brain games. However, considering the high cost of medication, as well as other alternative treatments, $80 for a used Nintendo DS Lite and copy of the Brain Age software sounds like an option worth exploring. Others may wish to try NDSBA in addition to the medication their child is already taking. As Fynn explained, his medication took care of the big picture, while the brain games seemed to help with the little details.

Practitioners can reference the results of this study when providing parents with options for their children. Many parents prefer to try non-pharmaceutical treatments first, and this study provides practitioners a new method to suggest.
Additionally, since children of all ages love technology, and tend to be engaged by electronic formats that provide instantaneous feedback (Wegrzyn, 2008), this treatment would probably be more positively received by patients, and therefore parents, than many other options that are available at this time.

This form of treatment could also provide support for teachers. Educators often feel helpless when they teach a child with ADHD, especially when the child’s parents refuse to even try medication. After all of the behavior management and organization strategies have been used, there are still those students for whom ADHD is a nightmare. Brain games are a form of treatment that could be kept within the school, or even within the classroom. Teachers could allow struggling students to play the games each morning during homeroom, at lunchtime, or recess. Then along with each student, they could evaluate the games’ usefulness in increasing the student’s ability to focus. Liability is not an issue considering the fact that, even if the games did not help the child’s engagement, they would at least provide the educational benefit of practicing basic math facts, memorization, and reading skills.

Even though this study focused on a specific subset of those with ADHD, the absence of risks makes this a viable option for anyone with the disorder. Several of the mothers in the study said they were going to try playing the games themselves, even though they did not have ADHD. Since some sort of positive outcome is practically inevitable, it is possible that brain games, as a form of treatment, could become one of the most favored forms of ADHD treatment currently available.

**Recommendations for Future Research**

The purpose of this study was to add to the research on non-pharmaceutical
alternatives for the treatment of ADHD. Specifically, it sought to determine if the use of brain games could increase the classroom engagement of students with ADHD. Six research questions relating to this intent were posed, and answered using data from a number of quantitative and qualitative instruments. Data analysis revealed many significant findings in relation to the research questions. Although the overall results were supportive of the researcher’s hypotheses, there were some limitations. The remainder of this section will be divided into three sub-sections. Improvements for the design of future studies, improvements for the instrumentation of future studies, and new directions for related studies will all be discussed.

**Improvements for the design of future studies.** The small number of participants in this study limited the scope of the implications and generalizability of the results. Additionally, it limited the choices for the research design. It is suggested that future research involve enough participants to have a control group, so that a more experimental design can be utilized. With a much larger number of participants, they could also be subcategorized by gender, age, type of ADHD, and medication status. Considering the older participants in the study were able to articulate their feelings and observances much better than the young ones, it is advised that participants be at least in the 7th grade if self-report is going to be used in collecting data. Participants younger than that appeared to have a difficult time with the metacognition necessary to thoughtfully describe any impact the games had made.
The shortened time span of this study was also a limitation. It is possible that after five weeks of treatment, the participants were feeling a difference in their ability to focus, but that it was just not enough time for the improvement to carry over to the classroom. Researchers interested in conducting similar studies should consider using the six-month timeline used by Kawashima (Kawashima et al., 2005). This would allow time to collect data for a pre-treatment phase, as opposed to just a pre-treatment session. Data could also be collected at multiple points during the treatment, instead of just at the beginning and the end. This would permit the researcher to study the effects of the treatment over time. For instance, is the treatment more or less effective after six months of use than it is after three months, and how quickly do the benefits occur after beginning use of the games?

It is suggested that future studies be double blind so that researcher data collection and interaction with participants is minimized. This would help reduce any personal bias in the data analysis and formation of conclusions.

Another limitation to this study was the threat of hypothesis guessing (Colosi, 1997). Since the participants and their parents were fully informed of the purpose of the study, it is probable the participants guessed that the researcher anticipated an increase in their ability to focus as a result of the games, which could have influenced the information they provided. The researcher suggests that, for future studies, measures should be taken to limit the information provided to participants, to only that which is required by the International Review Board.

An ideal research design would allow the research team access to the participants while they were at school. It would be advisable to have a researcher
administer the treatment to the participants each morning. This would increase the consistency of the treatment by eliminating external distractions, and ensuring that the participants completed the treatment in the same manner, for the same length of time each day.

Finally, although it is practically impossible to control all of the external factors that have an impact on participants, they should be asked not to make any major changes, other than the treatment, during the course of the study. This would include, but is not limited to, diet, use of illegal substances, physical activity, and mental activity. For instance, if a participant greatly decreased his or her caffeine intake two weeks into the study, it would be difficult to determine whether any changes in behavior were due to the use of the games or the decrease in caffeine. Similarly, if a participant took up Sudoku as a daily practice, this would be a confounding variable that could greatly affect the results. Since Sudoku is included on the Brain Age software, but is not one of the training games, it would be best to advise participants not to use this feature of the software, unless otherwise stipulated by the research.

Since the preceding suggestions for design were not followed in this particular study, generalizability of the findings are restricted. Therefore, the researcher does not intend to generalize these findings, but believes that the findings do warrant further research in this area.

**Improvements for the instrumentation of future studies.** Because participants kept a daily journal for seven weeks, the thoughtfulness and detail of their responses appeared to deteriorate over time. However, if this study had been
six months in length, the negative impact on journal entries would likely have been
even more pronounced. Although a timeline of six months is suggested for futures
studies, the use of daily journals is not suggested for a study of that length. It is more
probable that a weekly, rather than daily, journal entry would capture the needed
information, without causing an exorbitant amount of work for the participants. For
this reason, it is believed that weekly journal entries would likely contain more
detail and thought than daily entries. Another option would be to administer the
SARAC every week or two weeks, in lieu of a participant journal.

As mentioned previously, it would be beneficial for the researcher to have
access to the participants while they were at school. Since most teachers do not have
the time to observe the behaviors of individual students, or fill out weekly reports
about their behaviors, researcher observations of participants in their school
settings would be extremely valuable. While at the schools, the researcher could
also administer the SARAC to ensure that it was completed at specified intervals
throughout the study. If possible, it would be good for the researcher to get to know
some of the participants’ teachers, so they could encourage their help and
participation in the study as well.

In an ideal situation, funding would provide for an adequate research team
and resources. Taking this into consideration, along with the recommendation for a
six-month study, it is suggested that the number of EEG sessions be increased. They
could be conducted once per week, and involve a variety of activities including
closed-eye relaxation and playing NDSBA. This would allow researchers to better
track any changes in theta/beta ratios.
New directions for related studies. There are many directions that new studies about brain game treatment for ADHD could take. Many of these would focus on the differences in the treatment’s effect based on the demographics of the participants. For instance, as Aaron and Blake’s mother suggested, it might be helpful to determine if the onset of puberty changes the effects of brain game use? Along this same line of questioning, future studies could attempt to determine if elementary school children with ADHD would benefit from the use of brain games. Furthermore, would higher education students, or even older adults, see a reduction in ADHD symptoms with the use of this treatment. Other questions could include: Is this kind of treatment more helpful, or less helpful, for a particular age group? Gender? Ethnicity? ADHD subtype? Do students without ADHD benefit from brain game use? Do those who have had some sort of head trauma respond differently to the treatment?

Another line of possible future studies revolves around the use of stimulant medication. Is brain game treatment less, more, or as effective for ADHD patients who take stimulant medication versus those who do not. Additionally, a study could be conducted on non-medicated participants who had all, at some point, taken stimulant medication in the past. Then the results of those for whom the stimulant medication had not been effective could be compared to those for whom it had. Based on the idea that both stimulant medication and brain games seek to increase activity in the frontal lobe, the researcher postulates that brain game use might be more effective for the group who also responds to stimulant medication. Although it is not directly related to the brain game use, the researcher also suggests future
research be conducted to determine the amount of overlap between the 15% of ADHD patients who have excess beta (Clarke et al., 2001) and the 20% of ADHD patients who do not respond to stimulant medication (Fox et al., 2005). It seems feasible that those with excess beta would not benefit from additional stimulation, and the researcher hypothesizes that a large overlap would be found between these two subgroups. Additionally, due to Blake’s severe reaction to stopping the brain games, his mother made an interesting suggestion that a future study focus on whether the use, and then cessation, of brain games can cause withdrawal effects similar to those that can occur when stimulant use is terminated.

Other variables to consider in future studies are the time and frequency of use. For instance, do the games have to be played first thing in the morning to be helpful? As Blake’s mother stated, he was doing much better during his first two classes of the day, when using the brain games, but during the last two classes, he was still struggling. A study comparing morning use only, to morning and lunchtime use, would provide more guidance as to the number of times the games should be played each day for the best possible results. Additionally, a study designed to find the optimal length of play for each session would also be beneficial to those wishing to try brain games as a treatment. Other questions that could be studied are: Is it necessary to play the games every day? Does including weekend play improve the results? Do the treatment effects remain consistent over months or years of use?

Since participants in this study seemed to favor some of the brain games over others, it would be helpful to know if certain types of games within the brain game genre are more effective than others. Further research might seek to determine if
other forms of brain games, such as pencil and paper, are as effective. Do results differ based on whether the games are played in a secluded location with no distraction, versus a more distracting location? Do those who chose to play of their own will see different results than those who are forced to play by their parents? This area of research is so new; the directions new studies could possibly take are virtually endless.

Conclusions

The findings of this study bridge the gap between prior research on the frontal lobe’s connection to ADHD and the studies that have indicated brain games can stimulate this area of the brain. Based on the compilation of data, collected with the intent of determining the effect of daily brain game use on the engagement of students with ADHD, there is hope for ADHD patients searching for an alternative to medication. Data from seven of the nine instruments utilized in this study support the overarching hypothesis that the daily use of brain games can help decrease the theta/beta ratio of those with ADHD, while improving their ability to focus, and strengthening their executive functioning ability. The hope of the researcher is that those who read this study will share its findings with individuals affected by ADHD, and that the use of brain games will prove to be a monumental aid for treating the ADHD symptoms of the millions affected by this disorder.
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Appendix A

The Student’s Achievement-Relevant Actions in the Classroom – Student-report

How I Feel About School

1. I try hard to do well in school.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

2. I enjoy learning new things in class.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

3. When we work on something in class, I feel discouraged.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

4. In class, I do just enough to get by.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

5. Class is fun.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

6. In class, I work as hard as I can.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

7. When I’m in class, I feel bad.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

8. When I’m in class, I listen very carefully.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true

9. When I’m in class, I feel worried.
   A) Not at all true   B) Not very true   C) Sort of true   D) Very true
10. When we work on something in class, I get involved.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

11. When I'm in class, I think about other things.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

12. When we work on something in class, I feel interested.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

13. Class is not all that fun for me.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

14. When I'm in class, I just act like I'm working.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

15. When I'm in class, I feel good.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

16. When I'm in class, my mind wanders.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

17. When I'm in class, I participate in class discussions.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

18. When we work on something in class, I feel bored.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

19. I don't try very hard at school.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true

20. I pay attention in class.
   A) Not at all true    B) Not very true    C) Sort of true    D) Very true
### Appendix B

<table>
<thead>
<tr>
<th>Student’s Achievement-Relevant Actions in the Classroom (Teacher’s Report - TSARAC)</th>
<th>Not At All True</th>
<th>Not Very True</th>
<th>Sort of True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>When we start something new in class, this student</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. participates in discussions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. doesn’t pay attention</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. is enthusiastic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. thinks about other things</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. seems restless</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>In my class, this student</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. works as hard as he/she can</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. does just enough to get by</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. seems interested</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. is anxious</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. is angry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. does more than is required</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. seems unhappy</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. comes unprepared</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>When working on class work in my class, this student</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. appears worried</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. seems to feel good</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. appears frustrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. appears involved</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. seems uninterested</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>When I explain new material, this student</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. doesn’t seem to care</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. listens carefully</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>When faced with a difficult problem or assignment in my class, this student</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. “attacks” it</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. gives up quickly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. becomes frustrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. doesn’t even try</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. gets angry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. just keeps trying</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>When this student doesn’t do well on a test or assignment in class, he/she</strong>…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. feels terrible</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. bounces back</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. is devastated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. gets angry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. gets depressed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. works harder the next time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix C
Frontal Assessment Battery

1. Similarities (conceptualization)
   “In what way are they alike?
   
   A banana and an orange (In the event of total failure: “they are not alike” or partial failure “both have a peel,” help the participant by saying “both a banana and an orange are...,” but credit 0 for the item; do not help the participant for the two following items)
   
   A table and a chair
   A tulip, a rose, and a daisy
   
   **Score:** only category responses (fruits, furniture, flowers) are considered correct.
   - Three correct: 3
   - Two correct: 2
   - One correct: 1
   - None correct: 0

2. Lexical fluency (mental flexibility)
   “Say as many words as you can beginning with the letter ‘S’, any words except surnames or proper nouns.”
   
   If the participant gives no response during the first 5 seconds, say: “For instance, snake.” If the participant pauses 10 seconds, stimulate him/her by saying: “any word beginning with the letter S.” The time allowed is 60 seconds.
   
   **Score:** word repetitions or variations (shoe, shoemaker), surnames, or proper nouns are not counted as correct responses.
   - More than nine words: 3
   - Six to nine words: 2
   - Three to five words: 1
   - Less than three words: 0

3. Motor series (programming)
   “Look carefully at what I’m doing.”
   
   The examiner, seated in front of the participant, performs alone three times with his left hand the series of Luria “fist-edge-palm.” “Now, with your right hand do the same series, first with me, then alone.” The examiner performs the series three times with the participant, and then says to him/her: “Now, do it on your own.”
   
   **Score:**
   - Participant performs six correct, consecutive series alone: 3
   - Participant performs at least three correct, consecutive series alone: 2
   - Participant fails alone, but performs three correct consecutive series with the examiner: 1
   - Participant cannot perform three correct consecutive series even with the examiner: 0
4. Conflicting instructions (sensitivity to interference)

“Tap twice when I tap once.”

To be sure that the participant has understood the instructions, a series of three trials is run: 1 – 1 – 1. “Tap once when I tap twice.” To be sure the participant has understood the instructions, a series of three trials is run: 2 – 2 – 2. The examiner performs the following series: 1 – 1 – 2 – 1 – 2 – 2 – 2 – 1 – 1 – 2.

Score:
No error: 3
One or two errors: 2
More than two errors: 1
Participant taps like the examiner at least four consecutive times: 0

5. Go-No-Go (inhibitory control)

“Tap once when I tap once.”

To be sure that the participant has understood the instructions, a series of three trials is run: 1 – 1 – 1. “Do not tap when I tap twice.” To be sure the participant has understood the instructions, a series of three trials is run: 2 – 2 – 2. The examiner performs the series: 1 – 1 – 2 – 1 – 2 – 2 – 2 – 1 – 1 – 2.

Score:
No error: 3
One or two errors: 2
More than two errors: 1
Participant taps like the examiner at least four consecutive times: 0

6. Prehension behavior (environmental autonomy)

“Do not take my hands.”

The examiner is seated in front of the participant. Place the participant’s hands palm up on his/her knees. Without saying anything or looking at the participant, the examiner brings his/her hands close to the participant’s hands and touches the palms of both the participant’s hands to see if he/she will spontaneously take them. If the participant takes the hands, the examiner will try again after telling him/her: “Now, do not take my hands.”

Score:
Participant does not take the examiner’s hands: 3
Participant hesitates and asks what he/she has to do: 2
Participant takes the examiner’s hands without hesitation: 1
Participant takes the examiner’s hands even after he/she has been told not to do so: 0

SCORE:_____________

EXAMINER:______________________________ DATE:_____________
Appendix D

Journal Prompts

1) Did you play your Nintendo DS Brain Age this morning?
   - If YES... how many minutes?
   - If NO... why did you not play it?

2a) How did you feel about school during school today? (i.e. enthusiastic, bored, interested, disinterested, satisfied, angry, etc.)

2b) Was this the case for all classes or just some? If just some, which ones?

3a) How did you behave during school today? (i.e. showed initiative, passive, showed effort, gave up easily, good concentration, distracted, etc.)

3b) Was this the case for all classes or just some? If just some, which ones?

4) Can you think of anything that might have affected your engagement during your classes today? (i.e. forgot to eat breakfast, didn’t feel well, thinking about something else, really interested in a particular topic, least favorite class at my worst time of day, etc.)

5) Please write about anything else that comes to mind regarding your attitude about, and behavior at, school today.
Appendix E

Participant Pre-Session Questionnaire

Please answer the following questions to the best of your ability. Your identity will be kept private and your answers will be made anonymous if used in any analysis.

1. Which kind of ADHD have you been diagnosed with? Circle one:
   - Predominantly Inattentive
   - Predominantly Hyperactive
   - Combined Type

2. Are you currently taking any medication, drugs, or vitamins that may affect your alertness? (e.g., ADHD medication, anti-histamine, anti-depressant, , Super B complex)
   - Yes
   - No

   If yes, is it taken as treatment for your ADHD?
   - Yes
   - No

   Does it make you less alert or more alert than normal? Circle one: Less
   - More

3. Do you regularly play video games?

   If yes, how much? ________ hours per day / ________ days per week

   Kind(s) of games? Action/Adventure/Sports
   Role Play/Simulation Brain Games/Puzzle

4. Do you regularly (i.e., daily) drink caffeinated beverages and/or eat chocolate? (e.g., coffee, caffeinated soda, tea, hot chocolate, chocolate bar)
   - Yes
   - No

5. Do you smoke or were you a smoker?

   If you quit smoking, how long ago did you quit? _______________

6. Have you ever suffered from any short/long-term memory or speech loss due to a concussion or blow to the head?
   - Yes
   - No

7. Do you regularly (i.e., daily) engage in meditation/relaxation?
   - Yes
   - No

8. Please rate your overall current level of athleticism on a scale from 1-7, where 7 is very athletic, such as a trained athlete, and 1 is very sedentary. Circle one: 1 2 3 4 5 6 7

9. Which hand do you use for writing? Circle one: Right
   - Left
Appendix F

Participant Post-treatment Interview Questions

- In your mind, how have the last five weeks gone?

- Did you remember to play your NDSBA each morning or did you have to be reminded?

- When you were playing the NDSBA were you away from other distraction?

- Were you putting a good amount of effort into the activities?

- Did you enjoy playing it?

- Could you tell any difference in your ability to focus at school or engage in class over the last five weeks?

- Did you remember to write in your journal each day or did you have to be reminded?

- Do you think the next couple of weeks will be any different since you will not be playing NDSBA each morning?

- Is there anything else that you would like to share with me that you feel is important to this study?
Appendix G

Participant Follow-up Interview Questions

- Did you play any sort of brain games during the last 3 weeks? What ones? How often?

- Could you tell any difference in your ability to focus at school or engage in class over the last two weeks?

- Could you tell any other differences in your behavior or symptoms of ADHD over the last two weeks?

- At what point did you start to notice a difference?

- Do you feel that the use or non-use of brain games make any difference in your ability to focus at school, engage in class, or manage any other symptoms of ADHD?

- Do you intend to resume use of Brain Age now that the study is officially over? If yes, how often will you play them, and for how long? If no, will you play other brain games? If no, why not?

- Is there anything else that you would like to share with me that you feel is important to this study?
Appendix H

Parent/Guardian Pre-treatment Questionnaire

1) What age was your child when you first started noticing he/she had signs of ADHD? __________

2) What were the initial behaviors that made you wonder if your child might have ADHD?

3) How long was it from the time you began noticing these behaviors to when you talked to a healthcare professional about the issue? __________

4) How old was your child at the time of diagnosis? __________

5) What finally made you decide to talk to a healthcare professional? __________

6) What methods of treatment have you tried so far, and what are your reasons for not continuing these treatments? __________

7) What is your biggest concern regarding your child having ADHD? __________

8) What are you hoping will happen as the result of your child participating in this study? __________

9) Is there any other information that you feel would be helpful or interesting to the researchers? __________
Appendix I

**Parent/Guardian Post-treatment Questionnaire**
* Please complete the day of or the day before the 2nd lab session.

1) From what you witnessed, did your child play his/her Nintendo DS Brain Age daily as requested?
________________________________________________________________________

2) Did your child have to be reminded to play the game, or did he/she remember on his/her own? ______
________________________________________________________________________

3) Did you notice any change in the behavior/attitude of your child from the beginning to the end of the treatment period? Explain. __________________________________________
________________________________________________________________________

4) If yes, at what point did this change start to occur? _________________________________

5) Did you notice any change in the school performance of your child from the beginning to the end of the treatment period? Explain. __________________________________________
________________________________________________________________________

6) If yes, at what point did this change start to occur? _________________________________

7) In your opinion, did the daily use of brain games help treat your child’s symptoms of ADHD? Explain. __________________________________________
________________________________________________________________________

8) Do you plan for your child to continue using the brain games daily when this study is over? ________
________________________________________________________________________

9) Are there any other thoughts that you would like to share with the researcher? __________________
________________________________________________________________________
Appendix J

**Parent/Guardian Follow-up Questionnaire**
* Please complete the day of or day before final lab session.

1) Have you noticed any change in the behavior/attitude of your child since he/she stopped playing
Nintendo DS Brain Age? Explain. __________________________________________________________

2) If yes, at what point did this change start to occur? ______________________________________

3) Have you noticed any change in the school performance of your child since he/she stopped playing
Nintendo DS Brain Age? Explain. __________________________________________________________

6) If yes, at what point did this change start to occur? ______________________________________

7) Did these two to three weeks of your child not using Brain Age change your mind about the daily use of
brain games to help treat your child’s symptoms of ADHD? Explain. ____________________________

8) Do you plan for your child to continue using the brain games daily when this study is over? ______

9) Are there any other thoughts or suggestions that you would like to share with the researcher? ____

______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
Appendix K

Video Questions

Mimi Episode 1 – Part 1
1) Who was the boy looking for?
2) What kind of card did the boy find that he had sent?
3) Who were the people that pulled up in the truck?
4) The man at the gate told them the Captain of the Mimi had gone where?
5) What are they all going to look for?

Mimi Episode 1 – Part 2
1) What is the name of the young girl who gets dropped off by her mother?
2) One of the scientists tells the young girl the Mimi was built for ___________ not speed.
3) How did the young girl say she got there?
4) How long has it been since the captain has seen his grandson?
5) Why was CT sent to stay with his grandpa on the Mimi?

Shipwrecked – Part 1a
1) What number was this episode?
2) What caused the captain to pass out?
3) What did it show CT bringing off of the ship?
4) Why was it not a good sign that the captain had stopped shivering?
5) Why did CT say they should get the branches from the bottoms of the trees?

Shipwrecked – Part 1b
1) What kind of injury did the man scientist have on his hand?
2) Why did CT break the top of the little tree?
3) Who did Rachel say had taught her to fix a split boat seam?
4) What did the captain’s clothes have to do with him becoming hypothermic?
5) How low did the captain’s temperature go?

Shipwrecked – Part 2a
1) Why did CT climb the tree?
2) What kind of place had they landed?
3) What did the beeping of the receiver tell them?
4) What did CT learn from climbing the hill and seeing an island?
5) When they were all waking up, why did Rachel say their whale was smart?

Shipwrecked – Part 2b
1) What did they have to do to keep the Mimi from turning on her side when the tide went out?
2) What was wrong with the water in the jug?
3) Why did CT say he knew his way around the woods?
4) What did CT say had made him afraid?
5) CT said the only wildlife on the island were ___________ and a few other small animals.
Appendix L

Reading Questions

#1 - Scannon: Lewis and Clark’s Resourceful Mascot
1) What are Newfoundland dogs bred for?
2) Which president sent Lewis and Clark on their expedition?
3) What was the purpose of the expedition?
4) What did Scannon catch all along the waterway, which the crew ate for food?
5) What city was the starting and finishing point for the expedition?

#2 - Blind Tom: Working Hero of the Railroad
1) Who invited Blind Tom to the transcontinental railroad celebration?
2) What benefit did the rail companies get from covering the most territory?
3) What was one of two things they thought had caused Tom’s blindness?
4) What was Blind Tom’s job?
5) What was hammered into the track at the completion ceremony?

#3 – The Pacing White Mustang
1) In what part of the United States did the Pacing White Mustang live?
2) The Osage Indians said he was a what?
3) Prizes were offered if someone could what?
4) The Pacing White Mustang commanded 150 horses in a battle against what?
5) What was protected in the middle of the circle of mares?

#4 – Sugar: Cross-Country Traveler
1) What was the only thing Mr. and Mrs. Woods could not get Sugar to do?
2) Where was the farm that Mr. and Mrs. Woods moved to?
3) Why didn’t they take Sugar with them?
4) How many miles did Sugar travel to get back to Mr. and Mrs. Woods?
5) How did Mrs. Woods know for sure that the cream-colored, copper-eyed cat was Sugar?

#5 – The Hemlock Pair: A Living National Emblem
1) For how long do eagles keep a mate?
2) Why was the bald eagle almost extinct?
3) In what state did this recovery program take place?
4) What did the men name the baby eagle that hatched?
5) What happened to the male eagle in 1981?

#6 – Balto: Brave Sled Dog
1) What were the dog sled teams trying to deliver?
2) What happened to the dogs if their paws got wet?
3) What did Kasson make paw shoes out of?
4) Why didn’t Kasson pass the materials off at the relay station?
5) Where is the statue of Balto?
Appendix M

Channel/Electrode Placement Diagram

- **Fp1**
  - Channel 2
- **Fp2**
  - Channel 1
- **F3**
  - Channel 5
- **Fz**
  - Channel 4
- **F4**
  - Channel 3
- **C3**
  - Channel 7
- **Cz**
  - Channel 8
- **C4**
  - Channel 6
## Appendix N

### Journal Analysis Chart – Fynn

<table>
<thead>
<tr>
<th>Date</th>
<th>Min./ Why didn’t play?</th>
<th>Feelings about school today</th>
<th>All classes? Which ones?</th>
<th>Behavior at school today</th>
<th>All classes? Which ones?</th>
<th>Factors affecting engagement?</th>
<th>Additional thoughts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-28</td>
<td>20</td>
<td>Bored, didn’t feel like doing anything</td>
<td>History, physics</td>
<td>When he couldn’t do something he’d put it off for later, but would partially start with it</td>
<td>All</td>
<td>First day back after spring break, really upset about being there</td>
<td>Didn’t want to be at school... could have affected focus</td>
</tr>
<tr>
<td>3-1</td>
<td>See explain. above</td>
<td>Felt better about school now that back in the swing of things</td>
<td>All</td>
<td>Paid attention for most part / Not really interested, able to focus</td>
<td>All</td>
<td>Did everything right</td>
<td>Had a test which caused him to be focused</td>
</tr>
<tr>
<td>3-2</td>
<td>20</td>
<td>Really focused throughout day, able to keep interest in most subjects</td>
<td>Not physics... discouraged because learning something new and couldn’t really understand</td>
<td>Good bit of effort, sometimes bored and daydreaming, but for the most part focused</td>
<td>All but math, had a test in there</td>
<td>Really focused on math test all day, may have caused him to miss other things in class</td>
<td>n/a</td>
</tr>
<tr>
<td>3-3</td>
<td>20</td>
<td>Somewhat interested today / “When I was able to do something right it encouraged me and when I couldn’t do something I would attempt it and if I couldn’t get it, it would discourage me.”</td>
<td>Physics and history / Interested the whole time in math</td>
<td>Showed a lot of effort, but would sometimes give up if he didn’t understand at all</td>
<td>All</td>
<td>Did all the right things</td>
<td>Attitude towards school was great because things were looking a lot better</td>
</tr>
<tr>
<td>3-4</td>
<td>10</td>
<td>Somewhat interested at times and really bored at others</td>
<td>All</td>
<td>Distracted most of the time / showed some effort and tried, but would give up easily</td>
<td>All</td>
<td>Forgot medicine which threw him off</td>
<td>Just wanted to get out because it was the weekend</td>
</tr>
<tr>
<td>3-7</td>
<td>15</td>
<td>Angry, seemed nothing was going his way, really disinterested</td>
<td>All</td>
<td>Didn’t show a lot of effort and just went through motions</td>
<td>All</td>
<td>Forgot medicine / Got really bad grade in 1st period</td>
<td>n/a</td>
</tr>
<tr>
<td>3-8</td>
<td>15</td>
<td>Felt a lot better, showed a lot of interest, really kept focus</td>
<td>All</td>
<td>Showed a lot of effort, got involved with all the lessons, able to focus all day</td>
<td>All</td>
<td>Forgot medicine, but didn’t affect him / Able to focus</td>
<td>n/a</td>
</tr>
<tr>
<td>3-9</td>
<td>20</td>
<td>Just another day, nothing really special, just going through the motions, slightly bored</td>
<td>All</td>
<td>Showed effort and got involved / Good focus for most part, but distracted easily</td>
<td>All</td>
<td>Forgot medicine, but didn’t affect him as much as it did before brain games</td>
<td>n/a</td>
</tr>
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</table>
### Appendix O

**Interview/Observation/Questionnaire Analysis Chart – Blake**

<table>
<thead>
<tr>
<th>Parent Questionnaires and Additional Comments</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>3-week follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>- first noticed signs at 2 (“like a tyrant”, easily agitated, very hyper – more than a normal 2 year old, minimal attention span)</td>
<td>- Mother indicated that he played his game with the exception of two days that he woke up late, and that he remembered to play it on his own because it was important to him.</td>
<td>- Email received from mother during the treatment removal period stated, “By the way, ‘Participant 4’ definitely NEEDS his brain game back. Although we have not seen a significant difference in ‘his brother’ (see participant 3 – difference subsequently realized), there is clearly a distinction between ‘Participant 4’s’ ability to focus and control himself, and his participation in early morning brain games.”</td>
<td></td>
</tr>
<tr>
<td>- talked to health care professional 2 years later because he was uncontrollable at school and very detached and distracted at home / diagnosed at 4</td>
<td>- Said he seemed to be much calmer, less defiant, less agitated, and more on task than normal, and she noticed this change at approximately the 2nd week of treatment.</td>
<td>- Mom said that 1-2 days after stopping the treatment the participant “immediately became more agitated, easily irritated, unfocused (all over the place).” She said he also became very antagonistic.</td>
<td></td>
</tr>
<tr>
<td>- currently takes Adderall</td>
<td>- She indicated that he had always been academically strong, so other than increased focus and intensity, there were no other changes in school performance.</td>
<td>- Approximately 2-3 days after returning from Spring Break, they received a significant increase of behavioral notifications from his school stating that he has been hyper, uncontrollable, loud, distracted, and disrespectful.</td>
<td></td>
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<tr>
<td>- concerned about his reaction to the symptoms when he is not medicated, becomes very frustrated when he can’t focus, hyperactivity causes irrational behaviors and makes his say odd or mean things to others</td>
<td>- She believes that the brain games help treat his symptoms and shared that he is “generally at his worst first thing in the morning. The decrease in impulse behavior and him being less agitated were priceless.’”</td>
<td>- They feel the games are responsible for the positive improvements made during the 5 weeks of treatment.</td>
<td></td>
</tr>
<tr>
<td>- hopes this study will make him able to focus more naturally, despite any benefit from the medication</td>
<td>- They plan to implement the brain games permanently and more frequently.</td>
<td>- They intend to resume the brain games immediately with greater frequency and extended time periods. Because the participant’s reaction was so prominent, they would be interested in knowing if the brain games can cause withdrawal effects similar to the eliminated use of stimulants, when stopped after regular usage.</td>
<td></td>
</tr>
<tr>
<td>- socially immature, peer to peer interaction is strained</td>
<td>- She shared that at a recent school conference it came to light that his behavior changes significantly during his last two class periods. She felt it might be worth investigating the length of time that the effects of the brain games have. She is considering having him use the games each day after lunch.</td>
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**Lab Observations /**

<p>| Participant 4 is an African | Participant stated that the 5 | He did not play any sort of |</p>
<table>
<thead>
<tr>
<th>Interviews</th>
<th>weeks of treatment went “good”. He said that he reminded his parents that he needed to play the game each morning.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- He indicated that he was sometimes away from other distraction, he put a good amount of effort into the games, and he thought they were fun.</td>
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<tr>
<td></td>
<td>- He felt like the games helped get him through the day, and he was less exhausted.</td>
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<td>- He remembered to write in his journal each day.</td>
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<td></td>
<td>- He felt that he would be less focused during the weeks that he doesn’t use the game, and plans to continue the use after the 2 weeks of no treatment.</td>
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<td></td>
<td>- He shared, and seemed proud, that he had gotten a brain age of 23 once.</td>
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<td></td>
<td>- His behavior seems passive in nature, but he did show interest in things such as what his brain plots from last session looked like.</td>
</tr>
<tr>
<td></td>
<td>- Displayed more signs of engagement (interest, pride, concentration, involvement) than disaffection (passivity)</td>
</tr>
<tr>
<td></td>
<td>- Displayed more signs of engagement (concentration, involvement) than disaffection (passivity?) – or just mellow because of his medication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brain games for last 3 weeks</th>
<th>- He could tell a difference in his ability to focus / distracted... even in classes where he was able to focus while playing the games.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- He said he felt like he was better in the mornings than prior to using the brain games, but his parents made it clear that he was having a difficult time again.</td>
</tr>
<tr>
<td></td>
<td>- He noticed the difference as school the first week back after Spring Break / his parents said that they noticed at home 2 days after he stopped playing the games... it was a dramatic change.</td>
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<td>- He feels that the use of brain games definitely has a positive effect on his ability to focus at school and control his behavior at school/home.</td>
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<td>- He says he will resume playing the games, and will play school mornings for 30 minutes, and some weekends.</td>
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<td></td>
<td>- He was more talkative than during the other two sessions.</td>
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<td></td>
<td>- Displayed more signs of engagement (interest, concentration, involvement, pride) than disaffection (distracted – kept asking about things pertaining to the study)</td>
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</table>
### Appendix P

<table>
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<tr>
<th></th>
<th>B.A. Check</th>
<th>x20</th>
<th>x100</th>
<th>read</th>
<th>l to h</th>
<th>syll #</th>
<th>head #</th>
<th>tri +</th>
<th>time</th>
<th>voice</th>
<th>no play</th>
<th>wkend play</th>
<th>day of post-treat lab</th>
<th>big (wk.days)</th>
<th>avg/day</th>
<th>avg/day w/BA</th>
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<td>8</td>
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<td>4</td>
<td>1</td>
<td>3</td>
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<td>Days not played: March 2, 3, 8, 9, 10, 14, 15, 16, 29; April 1</td>
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<td>21</td>
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<td>Days played: March 2, 9, 14, 20 (Sun), 22; + 10 days of “Brain Age Check” / participant was confused and thought that he could do either one</td>
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<td>Days not played: March 4, 11, 23, 24, 25 (23-25 on a class trip / Mom called prior to him skipping)</td>
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</tbody>
</table>

Note: Initial lab sessions that took place on the weekend were not included in the weekend play total.
Note: Average # of games per day was figured by adding all games played (not including brain age check) and dividing by the number of days played, including weekend play.
Note: “No Play” days are out of the 25 required days.
Note: The final column includes brain age checks (3 games each) in the game total before dividing by the number of days played.
Appendix Q

IRB Approval Letter

1/8/2011

Stacy Wegrzyn, Student
Department of Secondary and Middle Grades Education
1000 Chastain Road, #0122
Kennesaw, GA 30144-5591

Re: Your application dated 12/17/2010, Study #11-178: An Investigation of Brain Games as a Potential Non-pharmaceutical Alternative for the Treatment of ADHD

Dear Ms. Wegrzyn:

Your application has been reviewed by IRB members. Your study is eligible for expedited review under the FDA and DHHS (OHRP) designation of category 7 - Individual or group characteristics or behavior.

This is to confirm that your application has been approved. The protocol approved is participation in lab sessions designed for collection of EEG readings while participants complete tasks such as reading or watching a video; completion of a questionnaire; use of brain game equipment; and submission of a journal regarding focus at school. The consent procedure described is in effect. In reviewing your consent procedure for this study, your inclusion of the following special classes of subjects was taken into account: students, minors.

You are granted permission to conduct your study as described in your application effective immediately. The study is subject to continuing review on or before 1/8/2012, unless closed before that date. At that time, go to http://www.kennesaw.edu/irb and follow the instructions for closing/continuing your study.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact the IRB at irb@kennesaw.edu or at (678) 797-2268 if you have any questions or require further information.

Sincerely,

Christine Ziegler, Ph.D.
Institutional Review Board Chair
Appendix R

Research Study Assent Form

Study Title: An Investigation of Brain Games as a Potential Non-pharmaceutical Alternative for the Treatment of ADHD

Researchers:
Stacy Wegrzyn (researcher) 404-428-0133
Dr. Doug Hearrington (supervisor) 770-420-4323
Kennesaw State University
1000 Chastain Road
Kennesaw, GA, 30144

My name is Stacy Wegrzyn. I am from Kennesaw State University.

• I am inviting you to be in a research study about playing brain games, like Nintendo DS Brain Age, as a way to help treat ADHD so students can focus better in class. I am hoping to find something that students can do to help their ADHD instead of taking medicine.

• Your parent knows we are going to ask you to be in this research study, but you get to make the final choice. It is up to you. If you decide to be in the study, we will ask you to come to Kennesaw State University three times to work with us for about an hour. We will be doing several activities. For one activity, we will ask you six questions that will help us see how well you can focus. Then we will do an EEG, which is a test where we put a cap on your head and sensors will show us your brain activity on a computer screen. This does not hurt. While you are wearing the cap, we will show you a short movie and ask you to answer a couple of questions about it. Then we will give you a short story to read and ask you a couple of questions about it. Next you will answer some questions about how well you focus in school. We would like to make a video of your session so that we can go back and look at how things went. Nobody will see this video except for the researchers, and we won’t record you without your permission. Finally, we will show you how to use the brain game that you will be playing. For 5 weeks, you will play brain games for 20 minutes before school each day. Then when you get home from school each day, you will write down a few notes about how you behaved and felt about school that day.

• Our hope is that the use of brain games will help you focus so you can do better in school. Also, your participation could help us find help for many other people that have ADHD and need help, but maybe don’t want to take medication.

• We don’t expect anything bad to happen to you if you decide to participate in this research study, but some participants might get a little tired in the sessions at
Kennesaw State University, or might feel a little discomfort when answering questions about how they feel about school.

- If anything in the study worries you or makes you uncomfortable, let us know and you can stop. There are no right or wrong answers to any of our questions. You don’t have to answer any question you don’t want to answer or do anything you don’t want to do.

- Everything you say and do will be private. We won’t tell your parents or anyone else what you say or do while you are taking part in the study. When we tell other people about what we learned in the study, we won’t tell them your name or the name of anyone else who took part in the research study.

- You don’t have to be in this study. It is up to you. You can say no now or you can change your mind later. No one will be upset if you change your mind.

- You can ask us questions at anytime and you can talk to your parent any time you want. We will give you a copy of this form that you can keep. Here is the name and phone number of someone you can talk to if you have questions about the study:

  Name: Stacy Wegrzyn       Phone number: 404-428-0133

- Do you have any questions now that I can answer for you?

IF YOU WANT TO BE IN THE STUDY, SIGN OR PRINT YOUR NAME ON THE LINE BELOW:

Put an X on this line if it is okay for us to record you

__________________________  __________________________
Child name and signature       Date

Parent/Guardian, please check which of the following applies:

☐ Child is capable of reading and understanding the assent form and has signed above as documentation of assent to take part in this study.

☐ Child is not capable of reading the assent form, but the information was verbally explained to him/her. The child signed above as documentation of assent to take part in this study.

Name of parent/guardian who gave consent for child to participate

__________________________  __________________________
Signature of person obtaining assent       Date
Appendix S

Consent Form for ADHD/Brain Game Study

I agree/give my consent for ________________________________ to participate in the research project entitled “An Investigation of Brain Games as a Potential Non-pharmaceutical Alternative for the Treatment of ADHD” which is being conducted by Stacy Wegrzyn from Kennesaw State University, 1000 Chastain Road, Kennesaw, GA, 30144. I understand I can reach Mrs. Wegrzyn at 404-428-0133. This research is being supervised by Dr. Doug Hearrington, and he may be reached at (770) 420-4323. I understand that this participation is voluntary; I or my child can withdraw consent at any time without penalty.

The following points have been explained to my child and me:
1. The reason for the research is to determine if the daily use of brain games such as Nintendo DS - Brain Age can increase the classroom engagement of students with ADHD. The benefit that I may expect from it is the potential increase in ability to focus through the use of brain game treatment. The number of beta waves, or the fast brain waves associated with alertness, may increase, while the number of theta waves, or the slow brain waves associated with drowsiness, decreases. However, I realize that this is a research study, and there is a chance we may see no benefits from the treatment.

2. The procedures are as follows: All lab sessions will take place at KSU in the BrainLab located on the 2nd floor of the Burruss Building in Room 206. Participants will be asked to come to the lab once prior to the treatment period of five weeks, once at the end of the treatment period, and once about two weeks following the end of the treatment period. The sessions will not last more than two hours. Sessions will be recorded using a digital video camera. During the pre-treatment lab session, demographic information and personal characteristics related to the study will be recorded. Next, with the participant seated comfortably, the researcher will administer the Frontal Assessment Battery (FAB) which consists of six verbal prompts that test the participant’s conceptualization, mental flexibility, programming, sensitivity to interference, inhibitory control and environmental autonomy. Next the participant will be prepared for the electroencephalogram (EEG). The researcher will put a cloth cap containing small metal disks on the head of the participant. A small amount of gel used regularly in clinical laboratories will be placed on each disk and touch the hair and scalp. The disks will painlessly record brain activity. After placing the sensors, the participant will be asked to perform simple tasks such as watching a video or reading a passage, and then answering related questions that follow. The researcher will provide external, auditory, stimuli such as tapping a pencil. After the participant completes a set series of tasks, the researcher will remove the sensors. The participant will then complete the Student’s Achievement-Relevant Actions in the Classroom (SARAC), which consists of 20 statements regarding his or her feelings about school, 5 of each in the areas of behavioral engagement, behavioral disaffection, emotional engagement, and emotional disaffection. Participants choose 1 of 4 choices to best describe how they feel about each statement: not at all true, not very true, sort of true, very true. At the end of this session, the participant will be given the brain game equipment, and trained in its use. During the five weeks between the pre- and post-treatment lab sessions, participants will play the brain games for 20 minutes each morning before school, and maintain an electronic journal, where they will record their daily thoughts about their focus at school. The journal will be downloaded from the provided jump drive at the end-of-treatment session, and the jump drive will be collected when the participant returns for the final lab session approximately two weeks after treatment ends. During this lab session, participants will repeat the following procedures from the pre-treatment lab session: EEG while performing video/reading and question tasks, and SARAC. For the end-of-treatment lab sessions, participants will begin their sessions by using their treatment for 20 minutes, and then will repeat the procedures from the pre-treatment lab session. The FAB and SARAC are available for viewing upon request.
3. There are no risks anticipated as a result of participation in this study.

4. Potential discomforts or stresses associated with participation in this study are: If the lab sessions approach the time limit of 2 hours, participants may become uncomfortable. Some questions/prompts such as “When I’m in class, I feel bad” may result in some discomfort.

5. The results of this participation will be confidential and will not be released in any individually identifiable form without the prior consent of the participant unless required by law. Identifiable private information will consist of name and contact information. The name will be kept on the consent forms only. Consent forms will be kept in a secure cabinet in the researcher’s home. Subjects will be coded with a non-identifying number for their lab sessions and data collection. Data will be deleted after it is no longer being analyzed which will be no later than December of 2014.

6. Inclusion criteria for participation:
   - middle school or high school student (age 10-20)
   - medical diagnosis of ADHD
   * Note: Because of the nature of this study, those who participate in recreational drug or alcohol use will not be able to participate. If you are a recreational drug or alcohol user, just simply inform the researcher that you do not wish to participate in this study, and discontinue the completion of this form.

Signature of Investigator, Date

_____________________________/__________
Signature of Participant, Date / Age Participant’s Phone #

* Note: Participant’s email address is collected solely for the purpose of scheduling sessions and sending reminder notices. It will not be used for any other purpose, will remain confidential, and will not be given out to anyone.

Signature of Guardian, Date Guardian’s Phone # Guardian’s email
(If participant is under the age of 18)

PLEASE SIGN BOTH COPIES, KEEP ONE AND RETURN THE OTHER TO THE INVESTIGATOR
Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to the Institutional Review Board, Kennesaw State University, 1000 Chastain Road, #0112, Kennesaw, GA 30144-5591, (678) 797-2268.
## Research Questions and Related Data Analysis

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<tr>
<th>Research Questions and Hypotheses</th>
<th>Qualitative Data and Analyses</th>
<th>Quantitative Data and Analyses</th>
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| **RQ. 1:** What effect does the daily use of NDSBA have on theta/beta ratios of the ongoing EEG of students with ADHD? RQ. 1. H1: The post-treatment theta/beta ratios will be significantly lower than the pre-treatment theta/beta ratios. | N/A | - pre-treatment EEG  
- post-treatment EEG  
- follow-up EEG  
- theta/beta ratio analyzed through repeated measures ANOVA |
| **RQ. 2:** What effect does the daily use of NDSBA have on the self-reported engagement of students with ADHD? RQ. 2. H1: The post-treatment SARAC scores will be significantly higher than the pre-treatment SARAC scores. RQ. 2. H2: Aggregated data from journal entries will show patterns of increased engagement during the treatment period. RQ. 2. H3: Aggregated data from participant interviews will show patterns of increased engagement during the treatment period. | - participant journals  
- entries organized in a chart based on journal prompts / deductive reasoning used to look for patterns of engagement versus disaffection  
- post-treatment /follow-up interviews  
- organized in chart separating data by session / analyzed through direct interpretation | - pre-treatment SARAC scores  
- post-treatment SARAC scores  
- follow-up SARAC scores  
- repeated measures ANOVA |
| **RQ. 3:** What effect does the daily use of NDSBA have on the teacher-reported engagement of students with ADHD? RQ. 3. H1: The post-treatment TSARAC scores will be significantly higher than the pre-treatment TSARAC scores. | N/A | - pre-treatment TSARAC  
- post-treatment TSARAC  
- follow-up TSARAC  
- repeated measures ANOVA |
<table>
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| **RQ. 4**: What effect does the daily use of NDSBA have on the parent-reported observance of ADHD symptoms?  
RQ. 4. H1: Aggregated data from parent questionnaires will show patterns of decreased observance of ADHD symptoms during the treatment period. | - parent pre-treatment questionnaire  
- parent post-treatment questionnaire  
- parent follow-up questionnaire  
- responses recorded on organizational chart / analyzed using inductive reasoning and direct interpretation | N/A |
| **RQ. 5**: What effect does the daily use of NDSBA have on the observer-reported engagement of students with ADHD?  
RQ. 5. H1: There will be an increase in observer-reported engagement at the post-treatment lab session as compared to the pre-treatment lab session. | - observations of lab sessions: field notes and observation checklist  
- inductive reasoning and direct interpretation used to evaluate findings from lab observations | N/A |
| **RQ. 6**: What effect does the daily use of NDSBA have on the executive functioning of students with ADHD?  
RQ. 6. H1: The post-treatment FAB scores will be significantly higher than the pre-treatment FAB scores.  
RQ. 6. H2: The post-treatment VQ/RQ scores will be significantly higher than the pre-treatment VQ/RQ scores. | N/A | - pre-treatment FAB scores  
- post-treatment FAB scores  
- paired samples t-Test  
- pre-treatment VQ/RQ  
- post-treatment VQ/RQ  
- follow-up VQ/RQ  
- repeated measures ANOVA |