The effect of graphomotor exercises and music on normal children and children with attention deficit hyperactivity disorder

Lucy Ellen Heyming

THE EFFECT OF GRAPHOMOTOR EXERCISES AND MUSIC ON NORMAL CHILDREN AND CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychology:

General-Experimental Psychology

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December 2003

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Approved by:

[redacted]

Fred Newton, Ph.D., Chair, Psychology

12/1/03
Date

[redacted]

Eugene Wong, Ph.D.

[redacted]

Alan Kwasman, M.D.

ABSTRACT

The behavior of children with Attention Deficit Hyperactivity Disorder (ADHD), a syndrome characterized by inattention, hyperactivity and impulsivity, has a large impact on families, schools and society. Secondary symptoms include: difficulties regulating behavior, paying attention, motor planning, timing, and in handwriting. Diagnosis must be accomplished using a multiple method approach from two or more sources. Barkley's (1997a) model suggests dysfunction of behavioral inhibition as the controlling variable for ADHD, which adversely affects the motor system as well as executive functions. Although treatment with drug therapy is common and has been shown to reduce symptoms, it is temporary, and can have adverse side effects. For these reasons, many prefer not to use it. Alternative treatments have been shown to have some efficacy, especially when used with drug therapy. Dynamic Systems theory suggests that an intervention which combines graphomotor exercises, with music, may have a positive affect on a child's behavior and attention. A 2 x 2 pretest-posttest design tested the hypotheses that normal children and children with ADHD and who received the intervention, would significantly improve on measures of

attention, behavior inhibition, and handwriting. Sixty-six children, from three different schools, and from third to sixth grades participated. Half of the participants received treatment for eight weeks during regular school hours, while the other half served as a control.
As expected, the handwriting of ADHD children was significantly poorer than the handwriting of normal children, but there was no improvement as a result of the treatment. Although treatment main effects were not significant, two additional findings were of interest. Teachers rated the behavior of children with ADHD in the treatment condition from pretest to posttest, to have improved more than the behavior of normal children. Teacher and parent ratings were highly correlated.

ACKNOWLEDGMENTS

A project like this cannot be accomplished without the help of many people, each of whom I am very grateful for. I would like to first acknowledge Jeanette Farmer, whose program, *Training the Brain to Pay Attention the Write Way*, inspired me with its potential to help children with ADHD. I would like to thank the Diocese of San Bernardino for permitting me to work with their school children, and the principals, Mrs. Patricia Vesely and Dr. Mary Beth Blackett who had faith in me and this project. I would like to acknowledge the teachers, office personnel, parents and especially the children who grated me the privilege of working with them. Also, I would like to thank Dr. Fred Newton, Dr. Eugene Wong and Dr. Alan Kwasman for their guidance and support in helping me to create and finish this thesis. I also greatly appreciate the expertise of Dr. Ken Schultz in the statistical evaluations. In addition, I would like to thank Kathy Gray, Leone Kelly and Peggy Rondeau for their tireless and significant contribution by assessing the children's handwriting. And, last but not least, I would like to thank my husband, Frank, and family for their help and support of me for all these years while completing this project.

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CHAPTER ONE

ATTENTION DEFICIT HYPERACTIVITY-DISORDER

Introduction

Attention deficit hyperactivity disorder (ADHD) is a common developmental childhood disorder, diagnosed in about 3-5% of today's schoolchildren (Adesman & Wender, 1992; American Psychiatric Association [APA], 1994; Ferguson, 2000). In 1998 a conference sponsored by the National Institute on Drug Abuse, the National Institute of Mental Health, and the National Institutes of Health Office of Medical Applications of Research issued a statement outlining the scientific evidence supporting ADHD as a disorder, the impact of ADHD, the effective treatments of ADHD, and direction for future research (Ferguson, 2000). It was concluded that families, schools, and society in general are greatly affected by this disorder and that the costs of the negative consequences of the disruptive behaviors associated with ADHD are high (Ferguson, 2000).

Within families, ADHD is responsible for increased levels of parental frustration, martial discord, divorce, and medical care costs. In schools, children with ADHD have difficulty sitting still and paying attention in class, engage in a variety of disruptive behaviors, and often experience peer rejection (Ferguson, 2000). The disorder can affect both learning and social abilities (Taylor, 1997) and has been found to correlate with decreased academic progress (LeFever, Dawson & Morrow, 1999). Compared with normal children, those with ADHD were found to be impaired in their relationships with others, their school performance, and their extra-curricular activities (Szatmari, Offord & Boyle, 1989). Society in general has also been impacted by those with this disorder as they tend to consume a "disproportionate share of resources and attention from the health care system, criminal justice system, schools, and other social service agencies" (Ferguson, 2000, p. 4). The difficulties and impairments associated with ADHD are found across multiple settings and are likely to cause long-term adverse effects on academic performance, vocational success, and social-emotional development (Ferguson, 2000). In conclusion, ADHD is recognized as a major public health problem that is in need of further research in the areas of assessment, diagnosis, and treatment.

ADHD Categories and Symptoms

Primary Symptoms

According to the Diagnostic and Statistical Manual of Mental Disorders - IV (DSM-IV), the two primary features of children with ADHD include inattention and hyperactivity/impulsivity (APA, 1994). Nine symptoms are listed under each and six of the nine symptoms need to be present in one or the other for diagnosis. For diagnostic purposes, the DSM-IV defines three categories or subtypes of ADHD, including: attention deficit hyperactivity disorder-predominantly inattentive type (ADHD-I); attention deficit/hyperactivity disorder, predominantly hyperactive-impulsive type (ADHD-HI); and attention deficit hyperactivity disorder, combined type (ADHD-C). The behavior of individuals who are primarily ADHD-I is characterized by excessive distractibility, and chronic difficulties in organizing tasks, sustaining attention, paying attention to details, listening, and sustaining mental effort. The behavior of those who are primarily ADHD-HI is characterized by fidgetiness, the inability to remain sitting for long, excessive running about or climbing, difficulty in playing quietly, acting as if "on the go," talking excessively, blurting out answers in class, difficulty waiting for his/her turn, and/or often interrupting or intruding on others. Those who are ADHD-C have significant numbers of symptoms from both categories (APA, 1994). There is research which supports these three categories as subtypes (Hale, How, Dewitt, & Coury, 2001; Piek, Pitcher, & Hay, 1999; Semrud-Clikeman, et al., 1999). Although others suggest that symptoms of ADHD-HI are generally found in younger children, and that these symptoms give rise to ADHD-C type after the age of 7 (Houghton et al. 1999; Barkley, 1998). This suggests that there may be only two types of ADHD, ADHD-I and ADHD-C.

The symptoms of ADHD should be present before the age of seven years, for more than six months, and should be present in two or more settings, such as, home, school, or work (APA, 1994). Males are diagnosed with ADHD 3 to 7 times more often than females (Taylor, 1997). Eighty percent of children with ADHD continue to be affected through adolescence (Wender, 1987).

Secondary Symptoms

Secondary symptoms have been noted, including difficulties in motor planning, timing, prioritizing, regulating behavior, using good judgment, paying attention to details, perceptual motor skills, and potential academic difficulties in reading, math, writing and handwriting (Banaschewski, Besmens, Zieger, & Rothenberger, 2001; Barkley, 1998; Barkley, 1997a; Piek, et al. 1999; & Taylor, 1990). Many classify ADHD as a syndrome, meaning it is a group of symptoms that tend to cluster together, but all children with ADHD won't have all the symptoms associated with it (APA, 1994; Barkley, 1998). Taylor (1997) sums up the essential features of ADHD as "a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than that typically observed in persons at a comparable level of development" (p.773).

Children with ADHD have been found to have more difficulties with motor coordination than normal children (Barkley, 1997b; Carte, Nigg, & Hinshaw, 1996). Problems with motor development in children who have ADHD have been reliably documented and seem to be inherently part of the disorder. Denckla & Rudel (1978) found that hyperactive boys had developmentally immature coordination. Piek et al. (1999) found 56% - 69% of boys with ADHD, both ADHD-C and ADHD-I, had either fine or gross motor difficulties, and suggested that both groups were in need of therapy for motor difficulties. A symptom related to motor coordination and common to many children with ADHD is poor handwriting (Barkley, 1990; McMahon & Greenberg, 1977; Taylor, 1990; Wender, 1987). The handwriting of children with ADHD, often illegible and unplanned, is characterized by inconsistent letter size and shape, poor spacing within and between words, poor placement of letters on or between lines, frequent erasures, frequent omissions of letters or words, poor rhythm and flow, slow speed, letter reversals or inversions (Lerer, Artner, & Lerer, 1979). This finding is in line with the diagnostic criteria of DSM-IV for children with ADHD, in that they "often fail to give close attention to details or make careless mistakes in schoolwork, work, or other activities," and, that they "often have difficulty sustaining attention in tasks or play activities" (APA, 1994, p. 78).

Diagnosis

As there is no one test that can accurately determine if an individual has ADHD, a diagnosis of ADHD requires a detailed family history and the use of standardized behavioral rating scales collected from two or more sources (e.g. parents and teachers) (Barkley, 1998; Forbes, 1998; Taylor, 1997). The use of objective tests, such as continuous performance tests, has also been used to aid in the diagnosis of ADHD (Levy & Hobbs, 1997), but can be expensive and inaccurate (Schatz, Ballantyne, & Trauner, 2001; Trommer, Hoeppner, Lorber, & Armstrong, 1988) unless combined with other methods of diagnosis such as, standardized behavioral scales (Forbes, 1998). Hale, Hoeppner, & Fiorello (2002) suggest using a multi-method approach that incorporates both diagnostic interviews and behavior rating scales to assess symptoms of ADHD. Barkley's (1998) recommendations include these and add a medical evaluation, parental interviews, direct behavioral observations, and possibly a measure of cognitive functioning.

Etiology

Genetics

This paper will consider three approaches to understanding the underlying etiology of ADHD that support a neurological viewpoint as the basis of the disorder: genetics, brain imagining studies and the role of executive functioning.

Based on a variety of family and adoption studies, Jensen (2000) concludes that genetic factors play an important role in a large majority of cases of ADHD suggesting that this disorder is more biologically rather than environmentally based. However, Jensen also notes the importance of the impact of environmental forces contributing to ADHD. In studies of monozygotic twins (who have the same DNA pattern) in up to 92% of the cases, when one sibling has ADHD, the other twin also has ADHD. This is referred to as a concordance rate. Amongst non-identical twins, the concordance rate is only 33%. If upbringing was the most important factor in causing ADHD, then both the identical twins and the non-identical twins would be expected to have the same rates of concordance. However, if environmental forces were not in effect, then the concordance rate would not be expected to be as high as 33% for non-identical twins. These percentages illustrate both genetic and environmental factors are at work.

Martin, Scourfield and McGriffin (2002) studied the correlation between parent ratings and teacher ratings using monozygotic twins. These ratings were found to have a modest correlation and illustrated that ADHD is highly heritable. Furthermore, they suggested that the differences in the ratings may reflect the effects of different genes.

Jensen (2000) emphasized the need to identify the specific genes associated with ADHD to get a more accurate understanding of the underlying cause. He concluded that two genes are linked to ADHD, the dopamine transporter gene (DAT1) and the dopamine 4 (DRD4) gene, both of which are connected with the dopamine system. This system is influential in the same brain regions in which neuroimaging studies have shown brain structure abnormalities among those with ADHD.

Brain Imaging Studies

The second approach, brain imaging studies, provides another important source of information in understanding the cause of ADHD by investigating brain structure and function. In a review of research conducted with quantitative electroencephalograph (QEEG), magnetic resonance imaging (MRI), and positron emission tomography (PET), Chabot, di Michele, Prichep, & John (2001) concluded that there is substantial agreement amongst the findings between these imaging studies as well as across behavioral, pharmacological, and neuroanatomical studies, linking disturbances in cortical and subcortical functioning and children with ADHD.

Research using both electroencephalograph (EEG) and (QEEG) imaging has contributed to the understanding of the connection between brain abnormalities and ADHD. These tests measure the electrophysiological activity of the frontal lobes assessing functional performance (Monastra et al., 1999). For example, Risser, and Bowers (1993) studied children with ADHD using EEG measurements of cerebral \electric activity across the oculomotor, premotor, parietal, and occipital cortex. They found that children with ADHD had significantly higher polyspike activity and significantly more problems in cognitive processing on tasks requiring motor and visual analysis, even under stimulant medication.

Across several studies Chabot et al. (2001) found significant (QEEG) frequency abnormalities in children with ADHD. In particular, there was an excess of theta or alpha activity, involving the frontal and central regions of the brain. They concluded that two different but interconnected neural systems are involved in the generation of EEG within the theta and alpha frequency bands, with theta waves appearing to be generated within the septal-hippocampal pathway, and the alpha waves involved thalamocortical and cortical-cortical circuitry. Using QEEG, Monastra et al. (1999) found that children with ADHD had significantly higher scores for cortical slowing than normals in the prefrontal region of the brain in those with both ADHD-C and ADHD-I.

Magnetic resonance imaging (MRI) studies and functional MRI (fMRI) studies are other sources of neurophysiological information on possible brain abnormalities in those with ADHD. Evidence from these sources that the right prefrontal lobe and striatal regions are smaller in children with ADHD, providing a firmer foundation for the viewpoint that ADHD involves impairments in the development of the brain (Barkley, 1998). For example, Casey (2001), Wender (1987), and Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos (1990) reported that MRI studies show that children with ADHD do not demonstrate the typical right frontal asymmetry found in normal controls. Instead, the right frontal widths were smaller when compared to normal children. Also, Jensen (2000) reported on studies that showed a loss of normal brain asymmetry and smaller brain volumes of the prefrontal cortex and basal ganglia found in MRI studies on children with ADHD. Hynd and Voeller (1991) suggest that "the lack of the normal right > left frontal provides a less well developed or organized neural basis for the complex process regulated by the frontal lobes" (p. 10).

Functional MRI (fMRI) studies allow localized areas of the brain to be studied during a cognitive task activity which provide an opportunity to investigate the hypothesis that the impairments and symptoms seen in children with ADHD are related to deficits in brain functioning. For example, Jensen (2000) reported that regional blood flow was significantly lower in the striatum, anterior cingulate and prefrontal cortex in children with ADHD. Rubia et al. (1999) found subnormal activation of the right mesial prefrontal cortex and right inferior prefrontal cortex and left caudate during two motor response tasks using adolescents with ADHD. They concluded that ADHD is associated with subnormal activation of the prefrontal systems which are thought to be responsible for higher-order motor control.

Functional MRI studies have also implicated the involvement of the motor system and the frontal cortex, which is thought to be associated with executive functioning. This is confirmed by a study on normal subjects using fMRI which determined that the areas of the brain activated when subjects moved their hand or foot as if signing, to be the contralateral primary sensorimotor cortex, the adjacent superior parietal lobe, the supplementary motor area, the anterior cingulate, the thalamus, the basal ganglia, the cerebellar hemisphere and the vermis (Wing, 2000). Also, motor-regulatory systems difficulties, involving both sub-cortical and frontal systems, have been shown to be associated with ADHD (Hynd & Voeller, 1991).

Positron emission tomography (PET) examines changes in global metabolism and is another neuropsychological measure of brain activity that has been used in identifying abnormalities in the brains of those with ADHD. For example, Jensen (2000) reports that the severity of ADHD symptoms were linked with reductions in prefrontal cortical metabolism. PET scans showed decreased flow while adults with ADHD performed concentration tasks. Chabot et al. (2001) also reported on five studies using PET and found similar results indicating abnormalities shown by decreased glucose metabolism or rCBF in left frontal cortical regions, in bilateral prefrontal cortical regions, right temporal and posterior temporal cortical regions, in striatal, thalamic, and hippocampal regions.

PET has also been used to track cerebral activity of the motor system. For example, subjects who imagined writing single words showed involvement of the prefrontal cortex using positron emission tomography (PET) to track cerebral activity in normal humans (Decety et al., 1994). This finding confirms that part of the anterior cingulate cortex plays an important role in higher motor control and suggests that mental representations during observation of actions performed by others share common neural mechanisms with other covert aspects of motor performance, such as planning and programming (Decety et al., 1994).

The evidence presented by these neurophysiological studies illustrate that the areas of the brain responsible for the executive functions, including the prefrontal cortex, basal ganglia, caudate nucleus and the globus pallidus, are smaller or abnormal in children with ADHD. These areas are hypothesized to be important in regulating attention, inhibition and motor control. It can be concluded that the fairly consistent findings of abnormalities in the structure and function of the prefrontal striatal basal ganglia and cerebellar areas in children with ADHD, linked with the fact that these same areas are rich in dopamine receptors, and most of the psychostimulants used for treating ADHD have a dopamine site of action, suggests a common neurological origin of the disorder (Jensen, 2000).

Executive Function

A third approach to understanding the underlying etiology of ADHD will be considered. This approach will address the underlying causes of ADHD by investigating hypotheses regarding the relationship of deficiencies in executive function processes and the symptoms of ADHD. Executive function (EF) is well recognized as occurring in the frontal lobes and believed to be important in a variety of ways (Brown, 2000; Hynd and Voeller, 1991). For instance, executive function enables the individual to function effectively in planning and decision making, inhibit behaviors that interfere with goal achievement, and regulate motor behavior (Brown, 2000; Hynd and Voeller, 1991). In support of this, studies on subjects with frontal lobe damage show a loss in the ability to plan, carry out or comprehend complex actions, they have difficulty focusing attention, and are easily distracted by irrelevant stimuli (Ornstein & Thompson, 1984). Casey (2001) comments that "the most commonly observed trait of frontal-lobe patients is difficulty regulating behavior" (p. 328). These are also symptoms often found in those with ADHD, suggesting that EF impairments are involved with ADHD (Brown, 2000).

To illustrate how the frontal cortex operates within the brain, Brown (2000) uses the metaphor of EF as a conductor of an orchestra. The conductor doesn't play a musical instrument in the orchestra, but does play a critical role in organizing, activating, focusing, integrating and directing the musicians as they play both routine and creative work. In a similar way, EF is able to activate, organize, integrate and manage the other functions of the brain. Using this illustration, it can be understood why deficits in this critical part of the brain (frontal cortex), can have such a large impact on the behaviors of attention, inhibition, and motor control.

Lubar, Swartwood, Swartwood, & O'Donnell (1995) support the hypothesis that executive functions are deficient by suggesting that the primary symptoms of ADHD, inattention and hyperactivity/impulsivity, "are really secondary outcomes resulting from an underlying neurological disorder" (p.84). Brown (2000) hypnotizes that EF refers to the self-regulatory processes that are responsible for organization of behavior and complex-problem solving, the same processes that have been identified in those with ADHD.

A review of research identifies eight aspects of executive function: planning, decision making (Hynd and Voeller, 1991; Lubar et al., 1995), inhibition of behaviors (Brown, 2000; Casey, 2001; Grodzinsky & Diamond, 1992; Sengstock, 2001), attention (including inhibiting, shifting and focusing) (Voeller & Heilman, 1988; Semrud & Clikeman et al., 1999), timing (accurately judging and reproducing temporal durations) (Barkley, 1997b), working memory (Barkley, 1997a; Sengstock, 2001), regulating motor behavior (Banaschewski et al., 2001), and regulating emotional behavior (Brown, 2000; Lubar et al., 1995).

Neuropsychological studies provide additional support to the viewpoint that ADHD is caused by deficiencies in these aspects of EF, and by confirming the link between brain abnormalities and cognitive and motor functioning in children with ADHD. For example, Carte et al. (1996) administered a battery of neuropsychological tasks to boys with ADHD and normals and found that the boys with ADHD had significantly more difficulty on non-automated language and motor tasks, and on a traditional frontal executive measure. They suggested that these deficits could represent frontal lobe processing problems related to self-monitoring and planning. In other research, Grodzinsky and Diamond

(1992) used a battery of neuropsychological tests sensitive to frontal lobe damage and found a relationship between ADHD and frontal lobe dysfunction, which they hypothesized indicated insufficient frontal cortical inhibitory control. Also, Carte et al. (1996), suggested that language deficits observed in children with ADHD could represent how frontal lobe processes (in this case mediated by frontal or frontal-striatal systems) are linked to the EF processes of self-monitoring and planning.

A link between attentional processes and EF has been suggested using human lesion studies. Semrud-Clikeman et al. (1999) hypothesized the frontal-striatal regions involved in arousal-motor regulation, are the systems that are directly involved in the ability to inhibit, focus, and shift attention. Sustained attention to tasks have been hypothesized to be compromised in children with ADHD.

Working memory and inhibition, two other executive functions, were tested by Sengstock (2001), who found that although age related gains in performance were evident within each of the executive function measures, when compared to normals, children with ADHD showed impaired performances within each of the executive functions.

The connection between ADHD and motor coordination has also been studied. Piek et al. (1999) found that children with ADHD had significantly poorer movement ability than the control children. The type and degree of movement difficulty differed between subtypes, such that, children with ADHD-I had significantly poorer fine motor skill, while children with ADHD-C were found to experience significantly greater difficulty with gross motor skill. Banaschewski et al. (2001) suggest that as a result of an ineffective behavioral response inhibition, children with ADHD have a deficit of self-control and goal-directed motor behavior, which seem to be a part of a pervasive deficit in executive functions. In addition, Kalff, et al. (2003) screened over 1,300 children and found that those with ADHD were in general less accurate and more variable in their movements than normal children or those with other psychopathologies. They suggested this reflects deficits in higher-order executive functions.

Two other studies note the effect of motor experience on cognitive development. Locomotor experience was found to improve children's spatial search (Yan, Thomas, & Downing, 1998), and repeated writing was found to facilitate children's memory (Naka, 1998).

In response to the hypothesis that deficits found in those with ADHD might be a function of generalized cognitive impairment, Brown (2000) suggests that deficits in those with ADHD "appear to be relatively specific to executive functioning...because executive dysfunction is evident in ADHD children with above-average intelligence and deficient performance is observed on frontal lobe tasks, but not on measures of temporal lobe functioning or on non-executive tasks" (p.21).

Of the two features proposed by DSM-IV to define those with ADHD, inattention and hyperactivity/impulsivity, Barkley (1997a) places the greater emphasis on the inhibitory deficits (hyperactivity/impulsivity- which he refers to as behavioral inhibition) as the central impairment. This in turn impacts the attentional and motor systems. He outlines a neuropsychological model of the executive functions of the brain which he then relates to ADHD. According to Barkley (1997a, 1997b), the executive functions of the pre-frontal cortex can be reduced to four aspects: working memory, internalization of speech, self-regulation of affect-motivation-arousal and reconstitution, each of which depend on behavior inhibition for optimal performance. Barkley (1997a) hypothesizes that these functions are interrelated, and influence the motor system to effect goal-directed behavior in a hierarchical manner. The consequence of this model is that a dysfunction in behavioral inhibition will adversely affect the motor system directly, and the four executive functions indirectly, which is what Barkley hypothesizes happens in those with ADHD.

There has been some support for Barkley's model of executive function which emphasizes behavioral inhibition as the controlling variable for ADHD. Mahone, Koth, Cutting, Singer, and Denckla (2001) found that children with ADHD and Tourette syndrome made significantly more intrusions on the California Verbal Learning Test for Children (CVLT-C), an indicator of inhibition error, than normals. Houghton et al. (1999) found impairments on five measures of executive functions in a sample of children with ADHD who did not have comorbid disorders.

In addition, Casey (2001) proposes that a disruption of inhibitory control is at the root of developmental disorders. This would include ADHD, where children have difficulty in suppressing inappropriate thoughts and behaviors. He suggests two brain regions are involved, the frontal lobes and the basal ganglia. These areas have been shown to have abnormalities in size, symmetry, and/or glucose metabolism using positron emission tomography (PET) and magnetic resonance imaging (MRI). PET studies revealed decreased metabolism in the frontal lobes of patients with ADHD, and MRI studies detected abnormalities in the size and symmetry of the prefrontal cortex and basal ganglia.

Casey (2001) hypothesizes that the basal ganglia are involved in inhibition of behaviors while the frontal cortex is involved in representing and maintaining information and conditions to which we respond or act. He suggests deficits in the inhibitory mechanism underlying the basal ganglia thalamocortical circuitry results in deficits in inhibitory control.

Other data which suggests that the link between ADHD deficits and executive function is not yet clear. Mahone et al. (2001) found no significant differences between children with ADHD and a control group on tasks of response organization. The ADHD group did not have a significant EF impairment, and their performance on fluency and list learning tasks was in the average range, but did show significantly more intrusion on verbal list learning trials, a disinhibition variable.

In addition, in another study which examined measures of executive functioning of both male and female children with ADHD and normal children using neuropsychological behavioral, emotional measures, and brief measures of academic achievement and intelligence, Deshazo (2001) found that the ADHD group's performance on the EF measures was not significantly different than normals. Deshazo suggested that a global EF deficit theory of ADHD is too broad and the disorder is more accurately described as one involving specific executive functions.

Within Barkley's model of ADHD is an aspect that is important to the present study, that of timing (Barkley et al., 1997). Sense of timing was found to be impaired in children with ADHD, as they were significantly less accurate at a time reproduction task that measured the child's ability to estimate temporal duration with distraction. Barkley, et al. (1997) postulate that the capacity to accurately judge and reproduce temporal durations is an executive function of the prefrontal cortex, specifically, the dorsolateral prefrontal cortex, and that children with ADHD may have an impaired sense of time, that is, the ability to accurately reproduce temporal durations, when compared to normal children.

Several studies support this, including Brown and Bennett (2002) who explored the relationship between timing and attention and found that practice reduced the interference effect in timing which they suggest supports the viewpoint that timing is very sensitive to changes in allocation of attentional resources, and is primarily a central executive function. Banaschewski et al., (2001) note that the symptoms of hyperactivity/impulsivity illustrate an inability to regulate motor behavior, thus hyperactive children have difficulties with motor preparation, timing, and adjustment. Koomar et al. (2001) also suggest that timing is related to motor planning and sequencing and add the aspect of rhythm.

The evidence from this review of the three approaches to understanding the neurological etiology of ADHD: genetics, brain imagining studies and the role of executive functioning, suggest that deficits in brain functioning, particularly executive functioning, are at the root of the difficulties that children with ADHD experience. Treatments and interventions that will affect them positively would necessarily have to impact this system in some way.

CHAPTER TWO

TREATMENTS

Drug Treatment

A statement issued by the National Institutes of Health Consensus Development Conference on the diagnosis and treatment of ADHD, concluded that both drugs (Ritalin-methylphenidate, Dexedrine- dextrophetamine sulfate, and Cylert, magnesium pemoline) and behavioral interventions have been found to be effective in treating the symptoms of ADHD in short term studies (Ferguson, 2000). Drug treatment is considered the single most effective treatment, improving attention span, concentration abilities and overall behavioral functioning and is more effective than behavioral interventions by themselves (Ferguson, 2000; Hynd & Voeller, 1991; Taylor, 1997). Taylor also reports that "substantial improvements in this area often produce other noticeable improvements in self-esteem and feeling of being in control, less moodiness and less variability in mood swings. These effects often result in better academic performance and behavior at school and at home" (p.773). Barkley (1998) notes that the stimulant medication treatment approach to ADHD is the most well-studied therapy in child psychiatry.

A large portion of children with ADHD who use stimulant medication are positively affected by its use. Over 200 studies on drug therapy for children with ADHD have shown that stimulant medication is effective in 95% of the cases and suggest there is significant improvement in 70% of affected children (Shaywitz & Shaywitz, 1984; Taylor, 1997).

Drug treatment for those with ADHD operates by increasing attention span and decreasing hyperactivity and impulsivity through neurotransmitters called catecholamines (dopamine and norepinephrine) (Hynd & Voeller, 1991; Taylor, 1997). Catecholamines are involved in the neural circuits of the brain which control motivation and motor behaviors, along with activity levels, restlessness, and responsiveness. These behaviors are mediated in different neuroanatomical systems, however, the same catecholamines control these functions. Interestingly, these behaviors are often found to be deficient in children with ADHD (Hynd & Voeller, 1991). It is speculated that drug treatment is effective in children with ADHD because it blocks the reuptake of dopamine and norepinephrine in pre-synaptic receptors, and increases their release into the synaptic space (Taylor, 1997). Drugs also act as agonists at the postsynaptic adrenergic receptors.

There is a difference of opinion about the breadth of effectiveness of stimulant medication in treating children with ADHD. Ferguson (2000), concluded that while the use of stimulants in children with ADHD has been found to improve core symptoms, there is little improvement in academic achievement or social skills. However, Risser & Bowers (1993) found improvement on cognitive measures and neurological dimensions. And, Shaywitz & Shaywitz (1984) concluded that positive effects of stimulants have been documented in a wide variety of areas, including, behavioral, social, perceptual performance, motor activity, impulse control attention regulation, and cognitive performance. For example, stimulant drugs have been shown to be effective in improving motor skills, such as handwriting skills by increasing visual-perceptual motor functioning (Lerer, Artner, & Lerer, 1979; Sprague, 1978; Taylor, 1990), and gross and fine motor coordination (Adesman & Wender, 1992).

The use of stimulants to treat ADHD has been controversial. In a study designed to determine the extent of the use of drug treatment for ADHD in school children versus the expected rate of ADHD, LeFever, Dawson, and Morrow (1999) found that the rate of medication usage was two to three times higher than expected. Lubar, & Lubar (1999) point out that the behaviors of inattention, impulsivity and hyperactivity will reappear within 3-6 hours after the last dose is given once the medication has worn off. In addition, there can be side-affects and problems with addiction.

According to Barkley (1998), despite the effectiveness of drug treatment for those with ADHD, there are public and professional misgivings. This is compounded by the fact that media coverage exaggerates its usage. Also some see hyperactivity as a myth arising from intolerant teachers, parents and inadequate school systems (Barkley, 1998). These concerns emphasize the need to consider and study new interventions which can ameliorate the various symptoms of ADHD.

Alternative Treatments

Among other interventions that have been tested are: dietary replacements, various vitamin, herbal or mineral regimens, biofeedback, perceptual stimulation and others. Ferguson (2000) concludes that although these other interventions have generated considerable interest, overall, the empirical evidence regarding these interventions is inconclusive. Hynd and Voeller (1991) suggest that the most effective treatment combines the use of stimulants and behavioral interventions.

<u>Psychological Treatments</u>

A number of psychological interventions have been used with ADHD children, several of which will be considered for the present investigation: cognitive-behavioral, attention training, neurofeedback, sensori-motor training, and physical activity training.

Cognitive-behavioral interventions involve teaching children with ADHD to use problem-solving approaches and to observe their own behaviors and develop self-control. These interventions have been proven to be helpful when parent and teacher training is included. Semrud-Clikeman et al. (1999) concluded that little support has been found for cognitive-behavioral treatment beyond effects already obtained from medication and behavioral parent training. However, Kerns, Eso, and Thomson (1999) reported that cognitive-behavioral intervention helped improve cognitive efficiency in children with ADHD. Also, Banaschewski et al. (2001) found that cognitive behavioral training significantly improved cognitive impulse control, but had no effect on hyperactivity and anxious-depressive/ aggressive behavior.

Neurofeedback

Neurofeedback is a form of biofeedback linked to a specific aspect of the electrical activity of the brain, such as frequency, location, amplitude, or duration of specific EEG activity. It is designed to enhance certain types of EEG activity either by itself, or to enhance certain types of EEG activity and decrease other types of EEG activity when it occurs concurrently (Lubar et al., 1995). ADHD children produce higher amounts of theta brain waves (4-8 Hz) and less beta (16-22 Hz) brain wave activity than normals (Lubar & Lubar, 1999). For children under the age of 14, reduction of theta activity appears to be the key factor associated with improvement in ADHD (Lubar et al., 1995). In addition to behavior change, it is hypothesized that cognitive training will alter the brain waves in the direction of theta inhibition and beta enhancement (Kotwal & Burns, 1996). It has been found that neurofeedback training is at least as effective as other treatment approaches for a variety of learning, behavioral, and physiological disorders when it is continued over a period of time and is augmented by other supportive measures (Richter, 1984). Lubar et al. (1995) confirmed the effectiveness of neurofeedback training as appropriate treatment for children with ADHD on objective measures (changes in EEG activity and on TOVA, a continuous performance test) and subjective measures (ADDES and WISC-R).

Attention Training

Attention training involves the direct tutoring of attention in children. It is based on Luria's (1973) concept that direct retraining can result in a reorganization of function. Attention Process Training (APT) involves the use of organized treatment tasks that emphasize sustained attention and are repeated until mastery is accomplished (Sohlberg & Mateer, 1987). They reported that brain injured subjects with attention-deficits made significant gains in attention using the Attention Process Training. They also conclude that therapy directed toward remediation of underlying deficit processes should be encouraged since observed changes on the dependent measure can be attributed to changes in attentional processing ability and not merely alterations in task performance. The intervention views attention as the ability to sustain focus over time and to adapt to differing environmental demands (Sohlberg & Mateer, 1987). Semrud-Clikeman et al., (1999), also report success with people with head injuries, children with learning disabilities and comorbid ADHD, and children with traumatic brain injury using this therapy. Using Luria's theory, they suggest that children with milder forms of ADHD may be able to reorganize cognitive structures and improve their ability to pay attention using attention therapy.

Sensorimotor Training

Sensorimotor Training is another intervention that attempts to ameliorate the symptoms of ADHD. In this case, the intervention is designed to develop basic perceptual and motor skills by performing structured movement activities. Banaschewski et al. (2001) found that hyperactivity in children with ADHD was reduced and sensorimotor coordination improved slightly after receiving sensorimotor training which included vestibulomotor stimulation exercises, movement coordination exercises, proprioceptive-tactile-auditory stimulation, visual attention tasks, goal directed behavior, and complex sports activities to train self-regulation. They concluded that sensorimotor training is a useful tool to support children with ADHD's sensorimotor abilities and emotional development, and to prevent an unfavorable course of disturbance of behavioral inhibition (Banaschewski et al., 2001). Another intervention which employed intense and frequent physical activity was found to improve the behavior of children with ADHD compared to controls (Wendt, 2000).

An intervention that combines aspects of sensorimotor training, physical activity, and attentional training that has been successful in treating children with ADHD is the *Interactive Metronome* program, in which children with ADHD clap and tap in time to a computerized metronome. The purpose of this intervention is to help participants improve their ability to selectively attend to a task while not being distracted by internal thoughts or external distractions (Shaffer, et al., 2001). After several weeks of daily sessions doing these gross motor exercises, the children who received the treatment were able to stay focused longer, had improved motor control and showed less aggressive behavior than the control group.

Dynamic Systems Theory

To better understand how this program might be able to bring about improvement in attentional abilities in children with ADHD, the dynamic systems theory used by occupational therapists can be employed. More traditional approaches view human behavior as the result of inner factors of the person, such as motivation, cognitive capacity, or neurological functioning (Kielhofner & Forsyth, 1997). While these internal factors are important to performance and behavior, the dynamic systems theory sees them as only one part of the equation, and as affecting behavior indirectly. Two other components, the task itself and the environment also play important roles in the resulting performance and behavior (Kielhofner & Forsyth, 1997).

Instead of a static system, the dynamic systems theory characterizes the human system as ever changing and unfolding as a consequence of its interactions with the external world (Koomar et al., 2001). As a person works, plays or performs, he is reorganizing and reshaping himself, thereby presenting himself with new possibilities of behavior. A new behavior is not just the consequence of a stable human system, but also the new behavior is dynamically reshaping the human system as it is being performed. Behavior can be viewed as the outcome of the interaction between the person, the task and the environment (Kielhofner & Forsyth, 1997).

Kamm, Thelen, and Jensen (1990) suggest four assumptions of the dynamic systems theory. First, that the human system is self organizing, meaning that order and patterns arise from the cooperativeness of many elements. Second, behavior is emergent rather than specified and evolves out of the interaction of multiple subsystems. Third, since organisms are complex, multiple-dimensional and cooperative, no one sub-system has priority over another for organizing behavior of the system. Each sub-system contributes to behavior in a cooperative, interdependent relationship. And, fourth, dynamic systems theory holds that development is non-linear meaning that the whole is more than the parts and cannot be reduced or analyzed in terms of simple subunits acting together. Because of this, small changes can have large effects, as they disrupt the current functioning and allow the person to seek other and potentially better patterns of behavior.

Kielhofner and Forsyth (1997) emphasize that the occupational therapist must pay careful attention to both the task and the context in which the task is being performed, in order to fully understand and influence performance. They also noted that the particular therapy used in an intervention is important as it "has the power to tease out of the patient unrealized or latent capacities" (p.104).

Up to this point, this investigation into interventions that will improve behavior and attention has mainly focused on viewing the child with ADHD in a traditional way. Instead, using the dynamic systems theory, one could address this same child as a human system which can dynamically change depending on contexts and interventions he/she experiences. The child's behavior can be seen as the result of many subsystems interacting together, and an intervention that uses an environment and task directed toward building rhythmicity and timing could possibly change behavior. A child who is dysfunctional can benefit from an intervention program designed to facilitate adaptation through active participation with goal-directed purposeful behaviors and activities (Gilfoyle, Grady, & Moore, 1981).

The *Interactive Metronome* (Shaffer, et al., 2001) contained the three elements suggested by the dynamic systems theory: the participants (boys with ADHD), the environment and a task, i.e. the *Interactive Metronome*, in which an interaction took place as measured by improved performance on both behavioral measures and motor measures.

An important aspect of this study was the timing and rhythmicity involved which Shaffer et al. (2001) suggested has the potential to influence motor planning. They further concluded that this increased ability in motor planning interacted with other factors such as learning opportunities, environmental demands, and clapping time to the metronome, "to influence patterns of self-regulation and functioning at home, in school, and with peers" (p.161).

Another program that may illustrate the dynamic systems theory in a similar way is Farmer's (1993) program, *Training the Brain to Pay Attention the Write Way* (TBPA), a multi-sensory graphomotor program. In this program the human system, a child, is being asked to perform a task, graphomotor exercises (requiring timing and sequencing). The environment is enhanced by providing the child with auditory input (the music) and the child is asked to write in time to the beat of the music. The child is given instant feedback as she/he compares her/his output to the standard copy, and works toward making her/his writing match it. The instructor encourages the students, motivating her/him to perform carefully and slowly, rather than quickly. Also, since the music is fun to listen to, it is motivating. When one exercise has been mastered, the child moves on to the next, which enhances interest.

CHAPTER THREE

TRAINING THE BRAIN TO PAY ATTENTION THE WRITE WAY

Introduction

The TBPA (Farmer, 1993) program contains two components, the graphomotor exercises and music at 100 beats per minute. The graphomotor exercises are similar to handwriting and use many of the same neurological processes, but are non-alphabetical. The advantage of using a non-alphabetical exercise is that it does not prevent children who are not yet able to recognize letters or create them to be able to take part in the treatment (Marcotte & Stern, 1997).

Handwriting

As stated earlier, the handwriting of children with ADHD has been noted to be poor (Barkley, 1990; McMahon & Greenberg, 1977; Taylor, 1990; Wender, 1987). This is evident since the processes involved with handwriting are those that are deficient in children with ADHD. Handwriting is a complex cognitive and motor skill (van Galen, 1991), that involves vision, attention, learning, and movement, and is learned through attentive imitation

(Grossberg & Paine, 2000). The complex, sequential movements of handwriting are broken down into distinct motor control synergies (muscle groups) whose activities overlap in time to generate continuous curved movements (Grossberg & Paine, 2000). Handwriting is an integration of verbal, perceptual and motor skills and in order to adequately perform handwriting, there needs to be sequencing skill, planning ability and memory ability (Alston & Taylor, 1987). In an investigation of the relationship between handwriting and visual-motor skills, Glidden, Sheslow and Adams (1997) suggest that handwriting may be a complex, integrative neurocognitive task that taps visual-motor skills, more fluid cognitive abilities and likely behavioral factors as well.

Corn-Hill & Case-Smith (1996) outline the performance components associated with handwriting as: kinesthesia (awareness of weight of an object and the directionality of joint & limb movement), motor planning (needed to plan, sequence and execute letter forms); eye-hand coordination (skillful use of the hand which is guided by the visual system); visuo-motor integration (the ability to visualize, assign meaning and manipulate a writing instrument); and in-hand manipulation (precise and rapid manipulation of the writing tool). Handwriting is a complex skill that is accomplished after a child has achieved and integrated underlying perceptual-motor performance components. As has been noted earlier, these are abilities that are deficient in those with ADHD. Some have concluded that handwriting disorders are clinical manifestations of faults of motor programming and execution (Margolin & Wing, 1983; Stott, Henderson & Moyes, 1987).

Barkley (1990) noted that handwriting has often been cited in the clinical literature to be less mature in those with ADHD. Whitmont and Clark (1996) suggest that children with ADHD may be more at risk for fine motor, than for gross motor difficulties, and handwriting may be their poorest domain. For example, Marcotte and Stern (1997) recently found handwriting to be significantly impaired in both the combined and inattentive subtypes of ADHD, though more so in the former than in the latter. Piek et al., (1999) found that ADHD-I type had significantly poorer fine motor skills, while ADHD-C had poorer gross motor skills. Doyle, Wallen and Whitmont (1995) found that fine motor skills were a relative deficit compared with gross motor skills in children with ADHD-C.

Research performed by Marcotte and Stern (1997) using the Repeated Patterns Test (RPT), gives evidence of the link between difficulties children with ADHD have with the fine motor skill of handwriting or graphomotor skills, and the neurological basis for ADHD. The RPT allows for the assessment of graphomotor output independent of linguistic demands, such as spelling, and letter and word formation, that are involved in the complex process of writing. In the RPT, the child is shown five patterns of increasing complexity on a sheet of paper, and is asked to continue the pattern across the paper.

Similar tests have been employed in neurological studies of adults and have been shown to be sensitive to frontal lobe impairment and executive function (Marcotte & Stern, 1997). It was found that children with ADHD-C and ADHD-I demonstrated impairments on the RPT as compared to normals. It was concluded that the qualitative difficulties the subjects demonstrated on the RPT appear to reflect the underlying problems with inattention, self-monitoring, and poor planning, the cardinal behavioral features of ADHD. These are the behaviors also conceptualized as being mediated by the frontal lobes. Performance on the RPT was not influenced by underlying deficits in visual or visuomotor integration (Marcotte & Stern, 1997). Farmer's (1993) intervention program, TBPA, uses similar graphomotor exercises to those employed by Marcotte and Stern (1997).

Music

The second component of the TBPA program is music. In the occupational therapy field, many studies have recognized the therapeutic effects of music (Paul and Ramsey, 2000). Covington and Crosby (1997) documented the positive effects of music in the treatment of patients with psychiatric disorders. Guzzeta (1989) suggested that different kinds of music may have either a stimulating or calming effect on the cardiovascular system. Thaut, et al. (1996) found the benefit of music and rhythmic stimuli was helpful in gait and balance retraining. It has been demonstrated that rhythmically structured sound patterns, such as simple dance tune in 2/4 meter, can entrain the timing of muscle activation patterns, measured by electromyography (EMG) and thus facilitate movement during rhythmic hopping movements (Thaut, Kenyon, Schauer, & McIntosh, 1999).

Studies have found a physiological effect of rhythm on he motor system and motor control in gait experiments on normals and stroke patients and patients with Parkinson's disease. Thaut et al. (1999) found results using the arms as well as the legs. They hypothesized that sound can arouse and raise excitability of spinal motor neurons mediated by auditory-motor circuitry at the reticulo-spinal level.

Purdie and Baldwin (1995) used electromyogram (EMG) studies to test the difference in upper muscle activity when subjects had auditory rhythm superimposed on a regular activity versus not having auditory stimuli. They found muscle activity to be smoother and more therapeutically favorable when auditory rhythm was used. These studies suggest that there are physiologically positive reasons to combine music with the graphomotor intervention.

Listening to music has also been found to increase the involvement of the subject in the activity (Magee, 1995). In another study that evaluated the impact of extra-task stimulation on the academic performance of children with and without ADHD, it was found that the children with ADHD did significantly better on arithmetic performance under the music condition than in the speech or silence conditions (Abikoff, Courtney, Szeibel, & Koplewicz, 1996). This finding supports Farmer's use of music as a way to motivate children and help improve their performance.

Music integrated with a variety of therapies such as speech-language therapy, physical therapy and occupational therapy has also been successful in ameliorating symptoms of the brain injured (Fletcher, 1992; Purdie, 1997).

A meta-analysis examining EEG studies of children's brain waves, reported a difference in brain activity in those who received musical training and those who did not (Flohr, Miller & Debeus, 2000). This supports the multi-modal approach of treatment proposed by Farmer (1993) using both graphomotor exercises and music.

Another consideration is the rate and tempo of the music that is used in conjunction with the task. Sandness (1995) noted that the beat of the music must fit the activity of the task being performed. It is best to have music that is not too fast for the activity or too slow. Since music has been found to change physiological responses such as pulse rate, respiration rate, blood pressure and muscle tension, the particular music used in the intervention is an important consideration (Steinberg, Guenther, Stilz, & Rondot, 1992). Thaut et al. (1999)

suggested that repetitive rhythmic auditory stimuli needs to synchronize with motor neural activity during a rhythmic motor task. They postulate that rhythm, the time-structure of music, is the essential element relating music to motor behavior because the motor system is sensitive to auditory priming and timing stimulation. Furthermore, they suggest that an interaction between auditory rhythm and physical response occurs and that this interaction can be harnessed for specific therapeutic, rehabilitative purposes. Farmer's program (1993), TBPA, is just such a therapeutic intervention which uses music at a particular auditory rhythm (100 beats per minute) and a rhythmic motor task, graphomotor exercises.

Research combining a graphomotor activity with music, in a therapy, has been performed. In a study using adult female survivors of childhood sexual abuse as subjects, it was found that audioscriptotherapy (an intervention that combines journal writing and music therapy), decreased the level of anxiety and depression and increased self-concept (McCollum, 2001). This provides evidence that an intervention combining both graphomotor exercises and music has proven effective in treatments on adults.

As cited earlier, ADHD is a significant health problem (Adesman & Wender, 1992; Ferguson, 2000) that continually needs to be addressed. As one of the most prevalent childhood developmental disorders, more investigation into possible interventions that replace or enhance the use of stimulants is needed. Although stimulants have proven to be the most effective treatment in treating the core symptoms of ADHD successfully, their use is controversial (Ferguson, 2000). A meta-analysis of interventions (Purdie, Hattie, & Carroll, 2002) used for children with ADHD suggests that although drug treatment has been shown to help the behavior of some children with ADHD, these effects do not translate into improved academic performance. They suggest using interventions that directly affect academic difficulties. In addition, it has been shown that drugs are most effective when used in conjunction with other treatments (MTA Cooperative Group, 1999). For these reasons, examining alternate treatments is important.

CHAPTER FOUR

THE CURRENT STUDY

Purpose

The purpose of the current study was to test the effectiveness of the multi-sensory program, *Training the Brain to Pay Attention the Write Way* (TBPA) on three variables: (1) attention, (2) behavior inhibition, and (3) quality of handwriting, using school children who have been screened as having the symptoms of ADHD. It was expected that the intervention, a task that combines timing and sequencing on a motor task (graphomotor exercises), and timing, sequencing and rhythm (music), can effect the executive and sensori-motor systems.

In addition to testing children with symptoms of ADHD, a group of normal school children served as the comparison group. There were two treatment conditions for each of these groups, (1) an experimental condition in which participants received graphomotor exercises and music treatment, and (2) a control condition in which participants received no treatment.

Hypotheses

The present study was conducted to test the following five hypotheses. First, that children with symptoms of ADHD in the experimental condition would improve from pretest to posttest by, (a) increasing attentional abilities as measured by the Attentiveness-D' (CPT II-D') subtest of the Conners' Continuous Performance Test- II(DV1), (b) increasing behavior inhibition as measured by parent's ratings (CPRS) and teacher's ratings (CTRS) using the Conners' Rating Scales-Revised (DV2), and (c) increasing the quality of graphomotor output as measured by the Evaluated Tool of Children's Handwriting (ETCH) (DV3). Second, that the children with symptoms of ADHD in the control condition would not significantly improve on these same three measures from pretest to post test. Third, that the children with symptoms of ADHD in the experimental condition would improve significantly more than children with symptoms of ADHD in the control condition on these same measures. Fourth, that children with symptoms of ADHD in the experimental condition would improve significantly more than both normal children in either the experimental condition or the control condition. And fifth, that normal children in the experimental condition would not improve significantly more than normal children in the control condition on the measures of attention (DV1) or behavior inhibition (DV2), but would improve significantly on the measure of quality of handwriting (DV3).

CHAPTER FIVE

METHODOLGY

Design

This study utilized 2 x 2 factorial quasi-experimental pretest-post test design. The first independent variable, the quasi-independent variable, was student statue with two levels: (1) children with symptoms of ADHD as determined by parental rating, teacher ratings and the CPT-II, and (2) normal children. The second independent variable was type of treatment with two conditions: (1) graphomotor exercises and music treatment, and (2) a control condition in which participants received no treatment and instead participated in normal school activities. The dependent variables were: (a) attention, measured the CPT II-D' subtest of the Conners' Continuous Performance Test-II (CPT-II), (b) behavioral inhibition, which was measured by the parent (CPRS) and teacher (CTRS) behavior ratings respectively, using the Conners' Rating Scales-Revised, and, (c) quality of handwriting, which was measured by the Evaluated Tool of Children's Handwriting (ETCH).

Participants

Two-hundred and fifty girls and boys from third through sixth grades were recruited from three parochial schools in Riverside, California. All children who agreed to participate in the study and whose parents gave consent took part in the study.

Data was collected on a selected pool of the students. The children were selected for data collection according to a two-part screening process. The first part of the screening identified a homogeneous group of participants as described below, and the second part of the screening differentiated those with symptoms of ADHD from normals. Those children whose parents did not give consent or who did not themselves agree to participate took part in the normal school activities in their classroom.

The first screening procedure included: (a) the use of school records to determine intelligence; (b) the use of the modified Child Health Questionnaire (Appendix A) (Collings, 2001) to determine the presence of major physical or psychological problems, specific sensory defects or any other comorbid functional or physical illness (e.g. mental retardation, seizure disorders, etc.) that might contribute to or otherwise be confounded with symptoms of ADHD, and, (c) the use of the Child Health Questionnaire or a vision screening using the Snellen chart to determine uncorrected vision problems. Screening proceeded in this manner: (1) if the child tested in the fourth stanine or above on the Stanford Achievement Test or had an IQ of above 80, according to school records, he/she was considered for the next criterion; (2) if the child had no major physical or psychotic problems or comorbid symptoms with ADHD according to the Child Health Questionnaire, he/she was considered for the next criterion; (3) if the child had good or corrected vision according to the Child Health Questionnaire or a vision screening using a standard eye chart, i.e., Snellen chart, he/she became a part of the pool of participants for the second screening process.

All children who could not be part of the second screening process because they do not meet these three criteria still participated in the study. They were assigned to either the treatment group or the no treatment group. If they were in the treatment group, data was collected only for the exit interview. If they were in the no treatment group, no additional data was collected or used for the purposes of this study.

Using only those students who met the three criteria of the first screening process, the second screening process took place to determine placement in either the symptoms of ADHD group or the normal group. This screening included the use of the Conners' Parent Rating Scale-Revised (CPRS) (Appendix B), the Conners' Teacher Rating Scale-Revised (CTRS) (Appendix C), and the scores of the Confidence Index and CPT II-D' subtests of the Conners' CPT-II.

T- Scores of 55 or less on the CPRS and the CTRS are considered average, indicating typical behavior (Conners, 2001). *T*-scores from 56- 60 are considered to be slightly atypical and borderline problematic, while *t*-scores from 61-65 are considered to be mildly atypical representing behavior that is possibly a significant concern. Finally *t*-scores higher than 65 indicate a significant problem.

On the Conners' CPT Confidence Index and CPT II–D' subscale, a *t*-score of 55-59 is considered mildly atypical, from 60-64 is considered moderately atypical and above 65 is considered markedly atypical (Conners, 2002). The Confidence Index score is a composite of seven performance measures: hit reaction time, standard error of hit reaction time, omission errors, commission errors, attentiveness D', standard error by ISI, and two other factors which can affect performance, age and gender (Conners, 2002). The Confidence Index provides an overall indication of the probability that a participant's responses best fit a clinical or non-clinical profile.

The second screening involved the following: (1) if the child had a *t*-score of 61 or above on three of the subscales of the CPRS and CTRS, i.e., the Cognitive Problems/Inattention subscale, the Hyperactivity subscale, or the ADHD Index (at least one in each of the CPRS and the CTRS), or if the child had a *t*-score of 61 or above on two of the CPRS & CTRS subscales (at least one in each test), and a score of 60 or above on the Conners' CPT-II Confidence Index or subscale, CPT II-D'; or if a child had a *t*-score of 61 or above on two of the CPRS and CTRS Cognitive Problems/Inattention Index, the Hyperactivity Index, or the ADHD Index, and a doctor's diagnosis of ADHD, then he/she qualified as having symptoms of ADHD; (2) if the child's *t*-scores on both the CPRS and the CTRS were 60 or less he or she became a member of the normal group; (3) if more than two of a child's *t*-scores were very close to placing him or her in the ADHD group (60 or above) on the CPRS and the CTRS, he or she was assigned to either the treatment group or the no treatment group, but his or her data was not be used for the hypothesis of this study.

From the Child Health Questionnaire, it was determined whether the participants were on medication or not. Regardless of whether or not the child was on medication to treat ADHD, he or she was accepted. It was reported that two children with ADHD were on regular medication at the time of the pre-testing.

Participants were matched by grade, age and gender, and then randomly assigned to one of the treatment conditions. Those in the symptoms of ADHD group were matched with each other, and those in the normal group were matched with each other.

In order to maintain group equivalency, the groups were similar on the following factors: scores on the CPT II-Confidence Index, CPRS and the CTRS. After all the participants are pretested, a random assignment procedure was used to form the four treatment groups. This selection process resulted in 66 participants, 32 female and 34 male, 44 normal children and 22 with symptoms of ADHD.

All testing and treatments were given at no cost to the participants. All participants were treated in accordance with the Ethical Principles of Psychologists and Code of Conduct (American Psychological Association, 1992).

Materials and Scoring

For this study the following materials were used: the program *Training the Brain to Pay Attention the Write Way* (Farmer, 1993), including daily lessons and a CD of the music for each lesson, informed consents for parents, children and teachers, the Conners' Continuous Performance Test-II (CPT-II), the Conners' Parental Rating Scale (CPRS), the Conners' Teacher Rating Scale (CTRS), the Evaluated Test of Children's Handwriting (ETCH), a lap-top computer, a demographic sheet, family history, debriefing for parents, children and teachers, pencils, paper, papers copied with the appropriate lessons, a CD player, a Snellen eye chart and a large tree.

Attention Measure

The Conners' CPT-II measures sustained attention, a cognitive ability which has been found to be deficient in children with symptoms of ADHD (DeShazo-Barry, Grofer-Klinger, Lyman, Bush, & Hawkins, 2001). The CPT-II is a 14-minute vigilance test during which letters are presented on a IBM-compatible computer display screen is considered to be a test of sustained attention, the capacity to maintain one's attention over an extended time. When a letter is presented on the screen, the participant must press the space bar, except when the letter "x" is presented they must refrain from pressing the bar. There are three performance variables, (1) number of correct responses (hits), (2) errors of omission (misses), and (3)errors of commission (pressing the bar inappropriately). There are six blocks of 60 trials, totaling 360 trials. Using the results of the CPT test, the CPT-II produces an overall indication of the whether the subject best fits in a clinical or non-clinical profile, called the Confidence Index (Conners, 2002). The Confidence Index is based on a discriminate function analysis and is considered a composite measure of sustained attention. A higher Confidence Index score indicates greater risk of ADHD.

For this study, a subtest of the CPT II, the CPT II-D', was used as a specific measure of attention, rather than using the Confidence Index, a composite measure. Scores on CPT II-D' indicate a participant's ability to distinguish between targets and non-targets (Conners, 2002), and have been used as a measure of sustained attention in a study with 10 year-old boys with ADHD (DeShazo-Barry et al., 2001).

The CPT-II was standardized on 1920 individuals from the general population from 30 sites around the United States (Conners, 2002). Standardized *t*-scores are available from data on 378 clinic-referred children with ADHD diagnosis. It is reported that the CPT-II has good sensitivity (.87) and specificity (.86) of overall index, as well as satisfactory reliability and validity, and is relatively free from practice effects. Split-half reliabilities range from .66—.95 and test-retest reliability over three months were highly satisfactory for most of the measures (Conners, 2002). Studies have found support for the use of the CPT-II in the differential diagnosis of ADHD, with the ability to classify group membership with 70% accuracy (Perugini, Harvey, Lovejoy, Sandstrom, & Webb, 2000), and support in determining treatment effectiveness with medication intervention (Conners, 2002). Before data was collected, participants received a practice test to make sure they understood the task.

Behavior Rating Scales

To measure changes in behavior inhibition, the short forms of two scales were used from the Conners' Rating Scales- Revised, the Conners' Teacher Rating Scale-Revised (CTRS), and the Conners' Parent Rating Scale-Revised (CPRS). The use of both parental and teacher reports gives the opportunity to measure differences in behavior in two settings, home and school, an important criteria for diagnosis of ADHD (American Psychological Association, 1994; Collett, Ohan, & Myers, 2003). Both tests are designed to test symptoms relevant to ADHD and related disorders and are designed for repeated and brief assessment (Volpe & DuPaul, 2001). Use of the short forms of the Conners' Scale is time efficient, while still maintaining a considerable degree of coverage (Volpe & DuPaul, 2001). Factor analysis has revealed three subscales on both the teacher and parent versions: Oppositional, Cognitive Problems/inattention, and Hyperactivity. In addition, an ADHD Index score is generated which provides an important way for identifying children with symptoms of ADHD, especially when combined with high scores in one or more of the other ADHD-related subscales. The CPRS was used to measure treatment effects in a longitudinal study

(Schachar et al., 2002), and the CTRS has been found sensitive to treatment effects in other research (Wainwright et al., 1996).

CPRS was standardized on 2,426 children (male and female) ages 3 -17 years and CTSR was standardized on 1,897 children (male and female) from 3 -17 years, so is gender and age specific. This data was collected in 95% of the states and provinces in North America (Conners, 2001). Six to eight week test-retest reliability was good (.62—.85). Internal consistency of the three factor derived subscales of the Conners Rating Scales -short form, range from .79—.95. Coefficient alphas for internal consistency were moderate ranging from .86—.94 on the CPRS, and .88—.95 on the CTRS. Coefficients of stability were adequate ranging from .62—.85 on the CPRS and .72—.92 on the CTRS- (Conners, 2001). Erford (1996) rated the overall reliability of the CTRS to be excellent. Concurrent and discriminate validity of the Conners' Scales appear adequate. Erford (1996) reported excellent convergent validity (.62—.90).

The CTRS is sensitive to externalized behavior in children, ages 4—12 in a classroom setting, including oppositional behavior, cognitive problems and hyperactivity (Sattler, 1992). The CPRS is sensitive to externalized behavior in children ages 3–17 in a home setting, including oppositional behavior, cognitive problems, and hyperactivity (Sattler, 1992). Behavior is rated on a 4 point scale (0= not at all, 1 = just a little, 2 = pretty much, and 3 = very much). Raw scores on each factor are transformed into *t*-scores (M = 50, SD = 10).

For purposes of this study, scores from the ADHD Index subscale of the CPRS and the CTRS were used for the pretest and posttest data. This subscale reflects deficits in behavior inhibition, is the best set of items which are able to distinguish normal children from those with ADHD (Conners, 2001). Therefore, a total of two scores were generated for dependent variable two (DV2) (behavior inhibition), one from the CTRS and one from the CPRS. These scores were not collapsed because information from two settings is important and inter-correlations between CTRS and CPRS are low (.33–.47 for males and .18–.52 for females). For the analysis, there were two different scores for behavior, one from the CPRS and one from the CTRS. These were analyzed separately.

<u>Handwriting Measure</u>

It has been reported that a high percentage of children with ADHD have difficulty with handwriting

(Barkley, 1990). To measure changes in quality of handwriting pretest to post test, the Evaluation Tool of Children's Handwriting (ETCH), a scale developed to assess the handwriting skills of children experiencing difficulties with written communication, was used. ETCH is designed to measure the functional written communication of children's handwriting, on the dimensions of legibility and speed (Amundson, 1995). Legibility is defined as readability or the ability to produce by hand, words, letters, or numerals which can easily be read at first glance, and out of context. Legibility is determined by counting the number of readable written words, letters or numerals in a sample of writing, dividing this by the total number of written words, letters, or numerals in that sample, and multiplying by 100. This yields a percentage score. There are seven individual tasks in the ETCH, each yielding a percentage score.

Composite scores were calculated from these seven tasks, on three levels: word legibility, letter legibility and numeral legibility. Higher percentage equals higher legibility. Three percentage scores were generated for legibility: total word legibility, total letter legibility and total numeral legibility. These three were combined and averaged to provide one legibility score that was used for the analysis. Average scores from children with borderline readability range from 75% - 80% (Amundson, 1995).

The ETCH has not been standardized. Seven day test-retest reliability has been determined for ETCH-M (manuscript), but not for ETCH-C (cursive) (Schneck, 1998). According to Diekma, Deitz, and Amundson (1998) these scores were adequate (.71 for total word legibility, .77 for total letter legibility, and .63 for total numeral legibility). Inter-rater reliability scores for trained examiners of ETCH-C using Pearson correlation coefficient ranged from .70—.90 (Amundson, 1995). No internal reliability data studies have been conducted. Koziatek and Powell (2002) reported adequate concurrent validity using fourth graders (.61 for total words and .65 for total letters). Percentage scores discriminating satisfactory from unsatisfactory handwriting ranged from 73% - 82% on ROC curves. This measure was chosen because it is the best available measure of finer changes in handwriting ability. For participants in this study, the ETCH-C will be used since all the them will be familiar with cursive.

Procedure

Written consent was obtained from all parents of participants in the study, the teachers, and the children in the study. The children whose parent's consented and who were screened to have symptoms of ADHD, were randomly assigned to either the treatment group or the no treatment group on the first day of week one. The group of normal children who met the screening criteria were also randomly assigned to either the treatment group or the no treatment group.

Testing on DV1, DV2, and DV3 was performed in the two weeks prior to the first TBPA treatment to quantify their abilities in three areas: attention (CPT-II), behavior inhibition (parents and teachers rated the child participants using either the CPRS or the CTRS), and handwriting (ETCH). The screening data from the ADHD Index of the CPRS and the CTRS, and the CPT II-D′ subtest of the CPT II constituted the pretest baseline data.

For the CPT II-D′, the participants were given a practice test both before the pretest and before the posttest. This practice administration lasts for 70 seconds and is designed to acquaint the participants with the test so that errors of omission and commission made during the actual testing would more likely be due to attention problems than from any difficulty understanding the task (Conners, 2002).

For the graphomotor and music intervention group, treatment took place five times per week, Monday through Friday, in the morning at School 1 and School 2, and the afternoon at School 3. The intervention lasted for a period of ten minutes per day, and for a total of eight weeks. Some weeks the schools had only four days of school and some Fridays the children had half-days. Due to differences in school schedules not all of the classes participated the same number of sessions. One class participated in 35 sessions, three classes participated in 36 sessions, five classes participated in 37 sessions and five classes participated in 38 sessions. During each session, an experimenter was present to introduce the exercises, train the students and keep them on track. The treatment regimen was designed and accomplished according to the instructions in the handbook, *Training the Brain to Pay Attention the Write Way* (Farmer, 1993). Each session for the children in the treatment condition consisted of two lessons which were performed while listening to the music designed for that lesson.

At the start of each session, the children were seated at a desk or table with a pencil and the two lessons for that day in front of them. Each exercise was marked either an angle-straight line (ASL) exercise (Appendix G), or garland-arcade-loop (GAL) exercise (Appendix H), and each had a complimentary piece of music that was played on a CD player while the students were performing the exercise. As stated in the handbook, at the beginning, the children were asked to stand and perform a gross motor warm-up exercise which lasted approximately one and one-half minutes. Then they were asked to sit at the desk and look at their lesson carefully. The experimenter pointed out the graphic pattern at the top of the first page and then ask the participants to trace the pattern with the forefinger of their dominant hand. Once the experimenter was confident that the participants understood how to make the handwriting movement, the children were instructed to pick up their pencil and begin the first exercise by imitating the graphic pattern on the first line as best they could while listening to the appropriate music for that exercise. The participants continued to draw the pattern across the page and then continued on to the next lines as long as the music was playing. This lasted approximately four minutes.

While performing this task, the children were encouraged to stay on task, do their best, and not to rush. They were asked to concentrate on their writing and to try to get into the beat of the music. The experimenter walked around the room to give feedback to the children on their performance, and after the music ended the children were asked to look at their work and to assess how well they had performed.

After the music for the first lesson was finished, the second lesson for the day began, using the same procedure as described above. When this was finished, the children were dismissed until the next day of school when they did the same thing. When all the children have mastered the exercise, usually four days or five, two new ones were introduced. There were 16 different exercises, so approximately two were used per week over the eight weeks.

While the treatment group participated in the handwriting and music exercises, the control group spent the same amount of time in normal school activities. This varied for each school and each class. The experimenter did not have much control over what activities the control group did during this time. In some cases the children attended computer class, in other cases, they did some quiet school work, or did an art project, played games, watched a movie, or went to the library.

The activities that the control group participated in at one point created a problem for the study. During the intake interview, the children were informed of their right to leave the experiment at any time. Some of them thought they might like to do the activities that the control group participated in more than their treatment group activities, and they asked to be dismissed. In order to keep the remaining children in the treatment group motivated to stay, the experimenter rewarded them once a week with incidental items. These were either a pencil, a pen, a sticker, or a cookie. At the end of the eight weeks, but before the posttests were given, the control group was also rewarded with these incidentals, so that all of the children received the same amount of gifts.

For two weeks after that last day of treatment, each child was post tested on the CPT-II and the ETCH. The parents and teachers were again asked to evaluate each child on the CPRS or the CTRS. Parents (Appendix I), children (Appendix J), and teachers (Appendix K) were thanked and debriefed.

CHAPTER SIX

RESULTS

Analyses

Two sets of comparisons were performed to test the hypotheses. First, within group comparisons were performed on each dependent measure, DV1 (attention- using CPT II-D' subtest of the CPT-II), DV 2 (behavior inhibition - both teacher ratings and parent ratings), and DV 3 (quality of handwriting), using paired *t*-tests to test for significant differences between pretest and posttest for each of the four treatment combinations: (1) symptoms of ADHD-experimental, (2) symptoms of ADHD- control, (3) normal-experimental, and (4) normal-control. Participant's pretest and posttest scores on the three dependent variables constituted the raw data for these analyses. Since this is a directional study, one-tailed *t*-tests were used in all paired *t*-tests.

Second, a two-way ANOVA for between-subjects designs was performed to determine the main effects and the interaction effect of the first and the second independent variables. Difference scores between pretest and posttest scores of each dependent variable constituted the data for the analyses. In addition to the ANOVA, pre-planned analytical comparisons were conducted using paired t-tests. An alpha level of .05 was used for all statistical tests.

Three students in the treatment condition dropped out of the program after taking the pretests, one in the normal group and two in the ADHD group. Missing values for the posttest scores were replaced using linear interpolation on SPSS. Also, one of the sixth grade teachers got ill half-way through the treatment and a new teacher took over her class, so the missing values for the CTRS posttest scores from the four sixth grade students in that class were replaced using linear interpolation on SPSS.

There will be three parts to the analysis of the results of this study. First, the statistical results of the ANOVA will be discussed, second each of the five hypotheses will be examined, and finally additional analyses and the results of an exit interview will be examined.

Analysis of Variance

A two-way ANOVA for between-subjects designs was performed to determine the main effects and the interaction effect of the first independent variable (student status) and the second independent variable (type of treatment), on each dependent variable. Difference scores between pretest and posttest scores of each dependent variable were used in this analysis.

For the handwriting quality dependent variable (ETCH), no interaction or main effects were found. The treatment program had no effect on the handwriting of either children with ADHD in the treatment or control group, or normal children in the treatment or control group.

Significant results were found on three of the remaining measures. First, a main effect (see Table 1 for

Table 1. Mean Difference Scores - CPRS

Group	N	Mean	SD
		ADHD	
Treatment	11	-1.91	8.58
Control	11	-4.27*	5.27
Total	22	-3.09	7.05
		Normal	
Treatment	22	0.41	5.55
Control	22	0.00	4.98
Total	44	0.21	5.21

Note: negative difference means indicate improvement.
* indicates significance, $p < .05$.

means) on student status on the CPRS revealed a significant difference between how parents rated the behavior of children, both the ADHD group and the normal group, $F(1, 62) = 4.53$, $p = .04$. Parents rated the behavior of children with symptoms of ADHD in both the treatment group and no treatment group significantly better than the behavior of normal children in either group from pretest to posttest. To pinpoint the locus of effect, mean difference scores were examined (Table 1), which indicated that parents rated the behavior of children with symptoms of ADHD in the no treatment group ($M = -4.27$, $SD = 5.27$) better than the treatment group ($M = -1.91$, $SD = 8.58$) from pretest to posttest. No significant treatment effect was found, $F(1,62) = .80$, $p = .37$. And no interaction was found, $F(1,62) = .39$, $p = .53$.

Second, a main effect on student status on the CTRS revealed a significant difference between how teachers rated the behavior of children who are ADHD or normal $F(1,62) = 9.20$, $p = .004$. Teachers rated the behavior of children with symptoms of ADHD in both the treatment group and no treatment group significantly better than the behavior of normal children in either group from pretest to posttest (see Table 2 for means). To pinpoint the locus of

Table 2. Mean Difference Scores — CTRS

Group	N	Mean	SD
		ADHD	
Treatment	11	-5.80*	10.19
Control	11	-6.18*	11.59
Total	22	-5.99	10.65
		Normal	
Treatment	22	1.41	3.23
Control	22	-1.19	7.15
Total	44	0.11	5.64

Note: negative difference means indicate improvement.
* indicates significance, $p < .05$.

effect, mean difference scores were examined (Table 2), which indicated that teachers rated both the behavior of children with symptoms of ADHD in the treatment group (M = -5.80, SD = 10.19), and the no treatment group (M = -6.18, SD = 11.59) better from pretest to posttest. No interaction was found, $F(1,62) = .30$, $p = .58$.

Concerning the CPT II-D′, an interaction was found in the ANOVA comparing the difference scores from pretest to posttest $F(1,62) = 4.68$, $p = .03$), meaning that on the test of attention, the effect of the treatment condition was

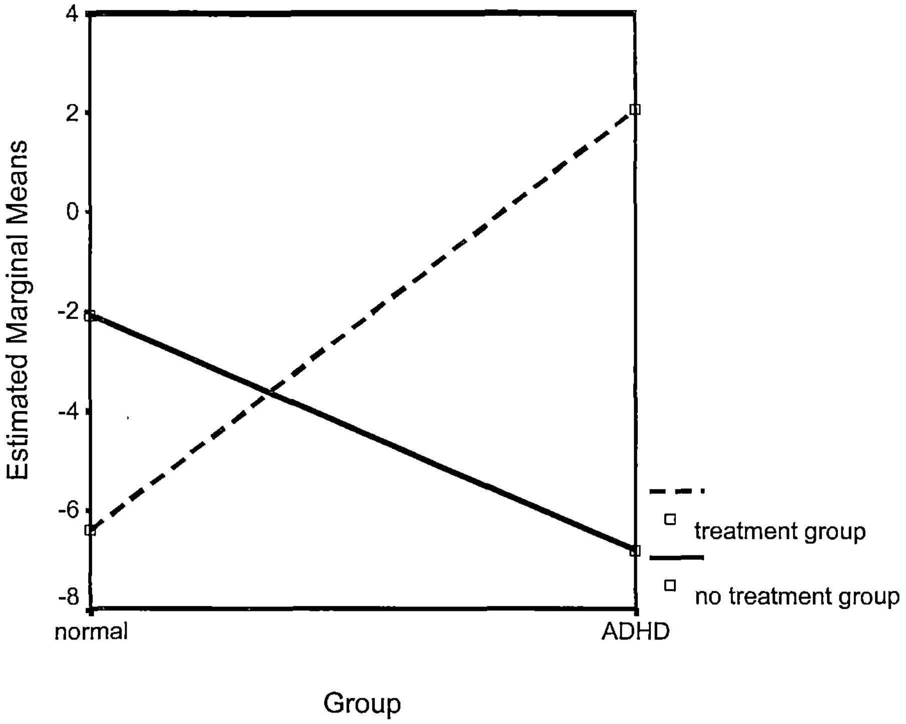


Figure 1. Interaction between ADHD and Normal Groups vs. Treatment and No Treatment Groups. Estimated marginal means of difference scores pretest to posttest on the CPT II-D′ used.

different for children with ADHD or normal children (see Figure 1). The mean scores of both the children with ADHD in the no treatment group and the normal children in the treatment group showed an improvement in their attention as measured by the CPT II-D′, (see Table 3). An examination of the means reveals that the attention of normal children in the treatment condition improved from pretest to posttest (M = -6.80, SD = 10.60), and the attention of children with ADHD in the no treatment

Table 3. Mean Difference Scores – CPT II-D'

Group	N	Mean	SD
		ADHD	
Treatment	11	2.04	40.59
Control	11	-6.80*	10.60
Total	22	-2.38	11.04
		Normal	
Treatment	22	-6.40*	13.23
Control	22	-2.07	11.16
Total	44	-4.24	12.29

Note: negative difference means indicate improvement.
* indicates significance, $p < .05$.

condition improved from pretest to posttest, ($M = -6.40$, $SD = 13.23$).

Hypothesis One

It was predicted that children with symptoms of ADHD in the treatment condition would improve their attention by decreasing their score the CPT II-D'; would improve their behavior by decreasing their scores on the CPRS and the CTRS; and improve their handwriting by increasing their score on the ETCH from pretest to posttest. These predictions were not supported since the ANOVA revealed no significant treatment effects.

Hypothesis Two

It was predicted that children with symptoms of ADHD in the no treatment condition would not improve their attention, would not improve their behavior on the CPRS and the CTRS, and would not improve their handwriting on the ETCH. This prediction was supported on the CTRS, and the ETCH. However, contrary to the hypothesis, significant results were found on two measures, the CPRS and the CPT II-D′. Paired sample *t*-tests revealed that children with ADHD in the no treatment condition improved significantly on the CPRS, $t(10) = 2.69$, $p = .05$ and the CPT II-D′, $t(10) = 2.24$, $p = .03$ (see Table 4 for means).

Hypothesis Three

It was hypothesized that the children with symptoms of ADHD in the treatment group would improve significantly more than the ADHD children in the no treatment group. A One-way ANOVA conducted using difference scores between pretest and posttest on each of the measures, i.e., the CPT II- D′, the CPRS, the CTRS and the ETCH, revealed no significant results.

Table 4. Comparison of Mean Scores — ADHD

	Treatment (n = 11)		No Treatment (n = 11)	
	Pretest	Posttest	Pretest	Posttest
		CPT II- D′		
M	46.64	48.67	49.87	43.07*
SD	9.61	7.61	12.08	13.13
		CPRS		
M	64.00	62.09	70.27	66.00*
SD	7.42	8.55	10.66	10.46
		CTRS		
M	66.73	60.93*	73.55	67.36
SD	10.21	13.51	9.54	8.88
		ETCH		
M	91.34	92.29	88.63	90.36
SD	6.56	5.15	9.45	11.92

Note. Lower scores are more favorable on the CPT-D′, CTRS and CTRS; higher scores are more favorable on the ETCH. *significant result using $p < .05$, one-tailed.

Hypothesis Four

Preplanned contrast comparison groups were created to determine if children with symptoms of ADHD in the treatment condition improved significantly more than normal children in either the treatment condition or the no treatment condition on difference scores between pretest and posttest on the CPT II-D′, the CPRS, the CTRS and the ETCH. A main effect on student status on the CTRS revealed a significant difference between how teachers rated the behavior of children from pretest to posttest, who are ADHD or normal, $F(3,62) = 3.49$, $p = .02$. Teachers rated the behavior of children from pretest to posttest with ADHD in the treatment group significantly better than normal children in either the treatment or control group.

Hypothesis Five

There are two parts to this hypothesis. First, it was hypothesized that normal children in the treatment group would not improve significantly more than the children in the no treatment group on the CPT II-D′, the CPRS, or the CTRS, and second, it was hypothesized that they would improve on the ETCH.

The first part of the hypothesis was supported, since examination of the ANOVA uncovered no main effect of treatment effect or interaction on any of the three measures (see Table 5 for mean scores). However, on the second part of the hypothesis, the analysis revealed no significant results on the ETCH either, indicating that

Table 5. Comparison of Mean Scores - Normal

	Treatment (n = 22)		No Treatment (n = 22)	
	Pretest	Posttest	Pretest	Posttest
		CPT II-D′		
M	49.40	42.99*	43.59	41.52
SD	7.51	12.37	12.66	11.53
		CPRS		
M	49.91	50.32	48.14	48.14
SD	6.47	7.15	6.00	6.49
		CTRS		
M	45.14	46.55	48.16	48.02
SD	4.89	7.44	11.30	11.84
		ETCH		
M	95.69	93.60	95.55	96.16
SD	3.32	7.17	3.77	3.08

Note. Lower scores are more favorable on the CPT-D′, CTRS and CTRS; higher scores are more favorable on the ETCH.
*significant result using $p < .05$, one-tailed.

normal children in the treatment condition did not improve their handwriting as expected, $F(1,42) = 2.85$, $p = .10$.

Additional Analyses

Correlations and Comparisons

A difference between the expected correlation from the normative sample on the CPRS and the CTRS, and the ADHD participants in this study was detected. In the normative sample, Conners' (2001) observed the correlation between the CPRS and CTRS rating scales for the ADHD-Index to be significant at 0.49 for both male and females. However, in the present study, the correlations between the CPRS and the CTRS were much stronger: female, $r = 0.77$, $p = .00$ ($n = 32$), and male, $r = 0.69$, $p = .00$ ($n = 34$).

No correlations between the CPT II and the short forms of the CPRS and the CTRS have been reported (Conners, 2001; & Conners, 2002). However, correlational analyses between an older version of the CPT and the long versions of the CPRS and CTRS show some correlations among the subtests and overall index. In the present study when using all the participants, there was a significant correlation between the teacher's rating and the CPT II-Index, $r = 0.32$, $p = .01$.

It has been suggested that the handwriting of children with ADHD is poorer than normal children (Barkley, 1990).

Examination of the means of the ADHD group (*M* = 89.98, *SD* = 8.06) vs. the normal group (*M* = 95.60, *SD* = 3.47) using independent *t*-tests revealed that the two groups were significantly different, $t(64)$, -3.97, p = .00, with the handwriting of children with ADHD rated worse on the ETCH than normals.

Exit Interview

An exit interview in the form of a questionnaire was given to all the participants of the treatment group, both normal children and those with symptoms of ADHD. Data for this analysis was gathered on those students who were part of the hypothesis testing as well as those who did not meet the selection criteria for inclusion into the hypothesis testing. This data was collected in order to determine how the children liked doing the graphomotor and music program, and if there was a difference between schools or by grade. One hundred-forty two questionnaires were filled out by the participants on the second to the last day, including 59 students in School 1, 48 in School 2, and 48 in School 3.

Three questions were asked: (1) Did you like this project?, (2) Did you like the handwriting exercises?, and (3) Did you like the music? The first question is more general, while the second and third question target the two

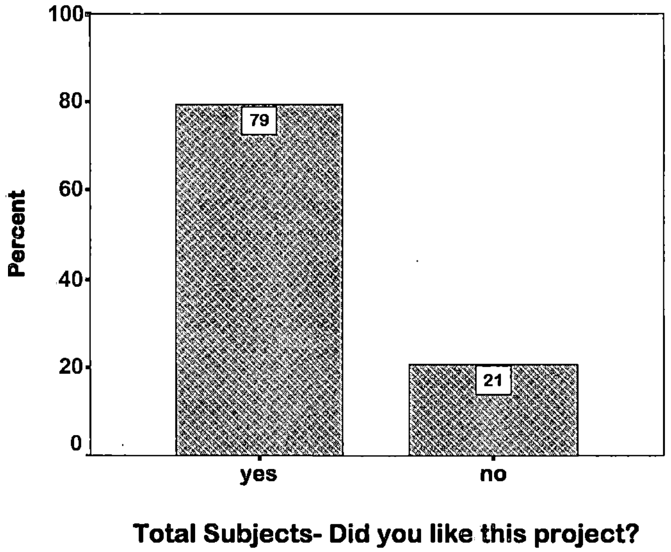


Figure 2. Percent response to question, "Did you like this project?" Total participants who answered this question - 140.

specific aspects of the program, handwriting exercises and music, to see if there are any differences between them. The results will be analyzed three ways, by total number, by school and by grade.

On question one, "Did you like this project?," more than three quarters of the 140 children who answered the question, agreed that they liked participating in the project (see Figure 2). One hundred eleven answered, "yes," and 29 answered "no".

An analysis by schools reveals that an overwhelming majority of the children at each school liked the program, but there was a difference (see Figure 3). Children at

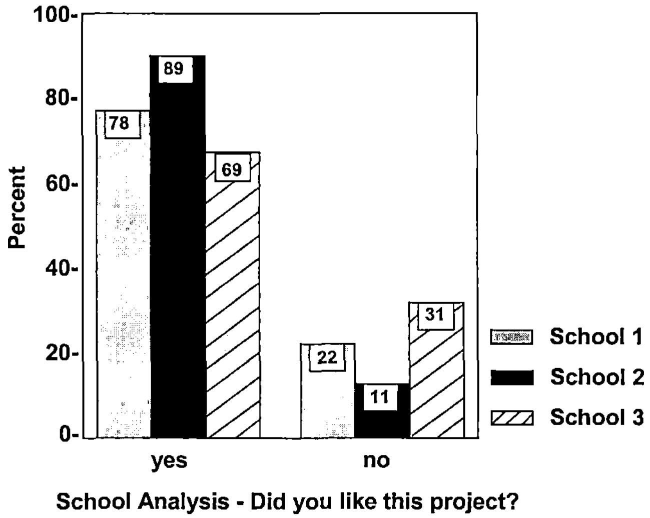


Figure 3. Percent of response to question, "Did you like this project?," divided by schools. Total students who answered this question - 140.

School 2, liked the project best, compared to a little over three quarters of the children at School 1, and somewhat less at School 3. These differences were not significant, $\chi^2(2, N = 140) = 5.45, p = .07$.

The grade analysis revealed that there was a significant difference between how children in the different grades responded to this question , $\chi^2(3, N = 140) = 11.61, p = .01$ (see Figure 4). Third and fourth graders had similar percentages in their positive response (92% and 89%, respectively), while fifth and sixth graders had similar percentages (67% and 68%, respectively). This indicates that while a great majority the students liked

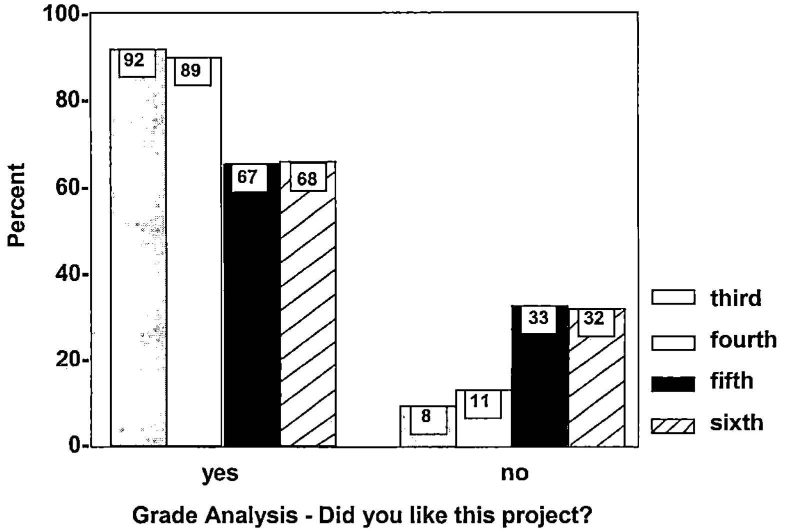


Figure 4. Percent of response to question, "Did you like this project?," divided by grades. Total students who responded - 140.

doing the program, older students did not like doing this project as much as younger students.

For the second question, the participants were asked if they liked the handwriting portion of the program. Overall, 104 (74%) of the participants liked doing the handwriting exercises. A significant difference was observed in the schools analysis, χ^2 (2, N = 141) = 6.10, p = .05 (see Figure 5). A greater percentage of the participants at School 2 agreed that they liked the handwriting exercises than that in School 1 or School 3.

The grade analysis revealed that there was a significant difference between how third and fourth graders

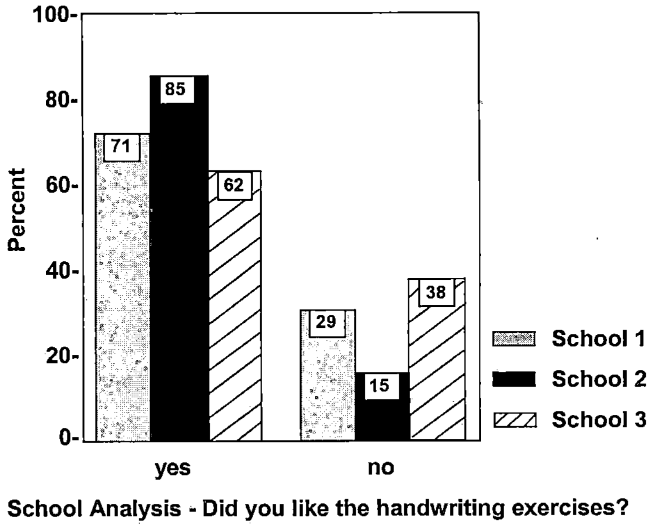


Figure 5. Percent of response to question, "Did you like the handwriting exercises?," divided by schools. Total students who responded - 141.

and fifth and sixth graders responded to this question, $\chi^2(3, N = 141) = 20.85$, $p = .000$. Third and fourth graders had high percentages (97% and 81%, respectively) in the response to "yes", while fifth and sixth graders had lower percentages (56% and 59%, respectively). This indicates that there was a large drop-off of desire to do these kind of exercises after fourth grade (see Figure 6).

The third question, targeted the music portion of the program. Overall, a smaller percentage (68%), but still a majority, of the children liked the music. The schools comparison revealed a significant difference in their preference for the music, $\chi^2(2, N = 137) = 9.06$, $p = .001$.

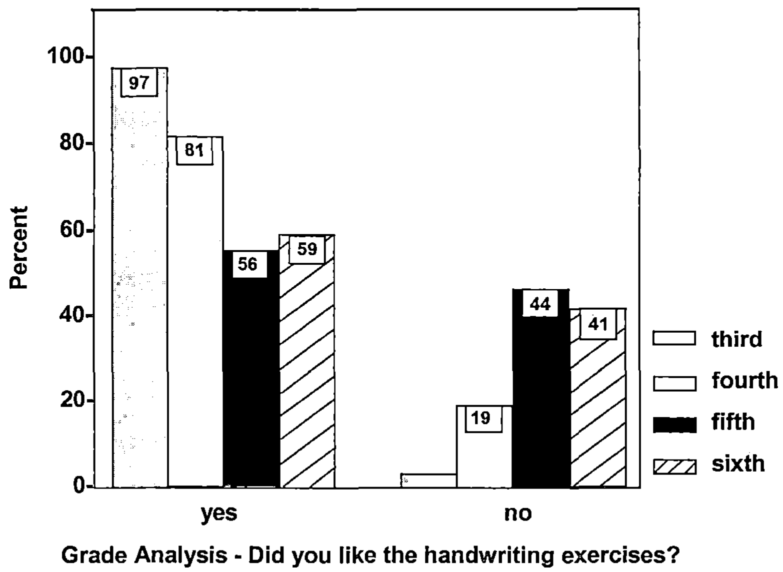


Figure 6. Percent of response to question, "Did you like the handwriting exercises?," divided by grades. Total students who responded - 141.

School 1 and School 2 overwhelmingly liked the music, while less than 50% preferred the music at School 3 (Figure 7).

A grade analysis of this question reveals a significant difference in preference for the music, $\chi^2(3, N = 137) = 28.94$, $p = .000$. Older students, in grades five and six, disliked the music more than younger students (Figure 8). A great majority of third and fourth graders liked the music, while only a minority of fifth and sixth graders did. Clearly, older students disliked the music of this program.

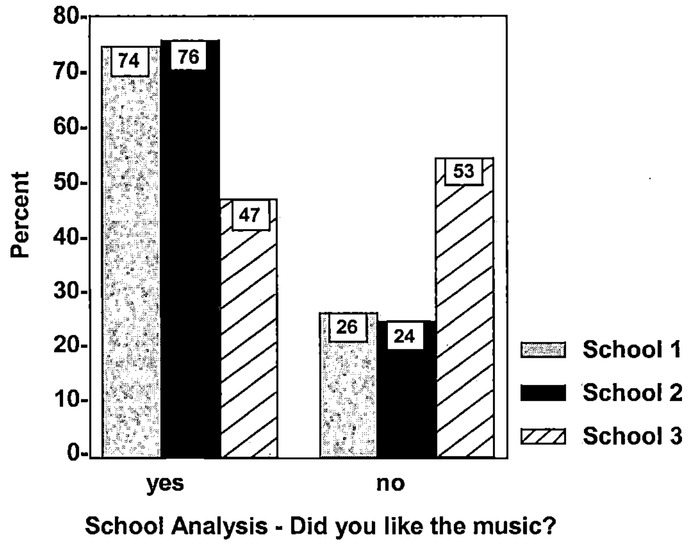


Figure 7. Percent of response to question, "Did you like the music?," divided by schools. Total students who responded - 137.

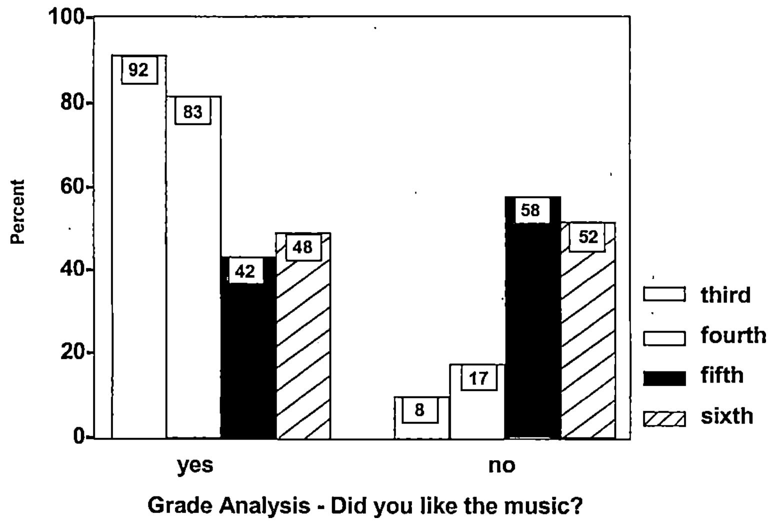


Figure 8. Percent of response to question, "Did you like the music?," divided by grades. Total students who responded - 137.

CHAPTER SEVEN

CONCLUSIONS

Discussion

In the introduction section of this thesis, literature was presented which suggested that an intervention which combined graphomotor exercises and music may help children with symptoms of ADHD improve their attention, their behavior and their handwriting. Five hypotheses were developed to test the effectiveness of this eight week program designed to help normal children and those with ADHD in third, fourth, fifth and sixth grades. Statistical analysis revealed no treatment main effects for any of the dependent measures. Overall, the hypotheses were not supported. One possible conclusion is that the program was not effective. However, there are a number of sources of variance that may also have led to the results of this investigation.

One source of variance that may have affected the results was the participant selection process. The two group design in this study is based on the assumption that the groups be clearly defined. However, the pretest means of the scores used in the selection process indicate that the ADHD group may not have been clearly defined. For example, the pretest means of the CPRS (67.14), and the CTRS (70.14) indicate that the parents and teachers both rated the behavior of the participants in the ADHD group as that expected of ADHD children (greater than 65 as suggested by Conners, 2001). But, the pretest mean scores of the CPT II-Index (50.16) and the CPT II-D′ (48.26), were more in the normal range. Therefore, it is unclear if the participants in the ADHD group were really exhibiting ADHD symptoms or not.

Another source of variance in the ADHD group, introduced through the selection process, may be that they contained different subtypes of the disorder. Participants were included into the ADHD group if they displayed scores of 61 or above on the subtests and indexes of the CPRS, the CTRS and 60 or above on the CPT-II. On the CPRS and CTRS, *t*-scores above 61 from two subtests, the Cognitive Problems/Inattention subtest, the Hyperactivity subtest, as well as scores of the ADHD index, were used for admission into the ADHD group. The Cognitive Problems/Inattention subtest is indicative of problems with concentration, sustained mental effort, and academic problems, and is associated with the subtype-ADHD-I (Conners, 2001). On the other hand, the Hyperactivity subtest is indicative of difficulty sitting still, restlessness and impulsive behavior, and is associated with ADHD-H and ADHD-C sub-types (Conners, 2001). It has been proposed by some that ADHD-I is a distinct disorder from ADHD-H or ADHD-C, with latter subtypes a result of impairment in the behavioral-inhibition system of the brain, and the former a result of different etiology (Barkley, 1997c, Brown, 2000; & Quay, 1997). Since this study was meant to test Barkley's model of executive function, it may have been better to have the ADHD group consist only of those with symptoms of ADHD-H and ADHD-C. However, the selection process used here did not do this.

Another source of variance contributing to a mixed ADHD group concerns the third criterion measure taken from the parent and teacher ratings, the ADHD Index. This index consists of 12 items, and is considered the primary indicator of overall attentional problems (Conners, 2001). For this study, equal weight was given to the two subtests (Cognitive Problems/Inattention which consists of six items and Hyperactivity which consists of six items) as well as the ADHD Index, which also contained items from the Cognitive Problems and Hyperactivity subtests. This may have contributed to variance by allowing different subtypes into the group.

The use of both the CPT II-D′ (a subtest of the CPT-II), and the CPT-II Index as criterion measures may have also introduced a similar variance into the group. Scores on both of these were used to determine inclusion into the ADHD group. The problem is that while both are measures of attention, the CPT II-D′ specifically measures discriminative power and sustained attention, while the CPT-II Index is a combination of 9 factors, including D′. No significant correlation between the pretest scores of the CPT-Index and CPT II-D′ was found in the present study. This may indicate that they measured different factors of attention and that using both these scores for the selection process may have helped introduce some variance.

A second source of variance that may have affected the results and caused a confound in the study having to do with another assumption of two group design, was that the ADHD group and normal group may not have been different from each other. In a comparison of the pretest means of each measure using independent *t*-tests, it was found that on three of the measures, the ADHD group was significantly different than the normal group, but on one, they were not.

On the CPRS the pretest mean for the ADHD group was 67.14, and 49.09 for the total normal group. On the CTRS, the mean for the ADHD group was 70.14, and 46.00 for the normal group. On the CPT-II-Index, the total mean for the ADHD group was 50.16, and 36.47 for the total normal group. But, on the CPT II-D′, there was not a significant difference between the means (ADHD, M = 48.26, and normal, M = 46.50). This indicates that on the measure of attention (CPT-D′), the normal group and the ADHD group were the same, instead of different as expected. In additional problem was created because the attention of both groups was in the normal range. One of the purposes of using children with ADHD to test this program was to see if their attention, which is thought to be impaired, would improve. Since the attention of the ADHD group was in the normal range, it would be difficult to show treatment effects. This indicates that the attention measure may have not been a sufficient one to measure for treatment effects with the group of children who displayed symptoms of ADHD.

As for the normal group, mean scores reveal that they were more clearly defined than the ADHD group. The pretest mean scores on each of the criterion measures were within the normal range. For the CPRS, the pretest mean score was

49.09, for the CTRS the pretest mean was 46.00, for the CPT-Index the pretest mean was 36.47, and for the CPT II-D' the pretest mean was 46.50. This illustrates that the normal group was more clearly defined than the ADHD group.

A third source of variance that may have prevented the program from being adequately tested concerns methodological limitations, which can be divided into two categories. One concerns problems with the implementation of the experiment, and the other concerns the limitations imposed by setting variables. Both of these may have played a part in the final results.

Concerning the implementation of the study, a factor that may have influenced the results of ADHD treatment group on the CPT II-D', were time constraints within the school environment. It was not possible to administer the CPT-II twice for the pretest, and twice for the posttest as recommended by Conners (2002). The two pretest scores are meant to be averaged to produce one pretest score, and the two posttest scores were to be averaged to produce one posttest score. Without using the CPT twice before the intervention and twice at the posttest, one cannot be certain if the results were an outcome of regression to the mean, or from the treatment itself (Conners, 2002).

A second possible limitation in the implementation of this study was the sample size. It is difficult to locate children with true symptoms of ADHD since they only comprise 3—5% of the population (Adesman & Wender, 1992; APA, 1994; Ferguson, 2000). Since this program was designed to be integrated into an educational setting (Farmer, 1993), it was decided to perform the study in schools, rather than a clinical setting. Three schools were selected in order to include as many children with symptoms of ADHD as possible. However, the number of children included in this study with symptoms of ADHD was somewhat small. Small N can contribute to small effects sizes and it is possible that null findings for the program were due to inadequate power to detect differences.

Another problem with the implementation of the study was that the dependent measures may not have been effective in detecting treatment effects. For example, measures chosen for the ADHD group may not have been effective with the normal group. Since children who are normal usually have normal attention, normal behavior and normal handwriting, it would be difficult to find treatment effects using the CPRS, CTRS and CPT-II if the pretest scores were very low (floor effect). This is illustrated in the teacher ratings (CTRS) of the normal group, but also true for the handwriting measure (ETCH). The pretest mean score on the CTRS was 46. A score of 46 on an participant's behavior would indicate a teacher gave only three to five points out of a potential of 36 points (depending on age) for behavior problems associated with ADHD to male participants, and zero to one point to females. This does not give much room for improvement! In fact, if there are changes in behavior, there is greater chance of it being rated worse. A similar effect may have been present with the ETCH, the measure of handwriting legibility. In this case, the pretest mean score of the ETCH for the normals was high (95.6%), indicating that they would have a difficult time improving their legibility (ceiling effect). The pretest mean *t*-score (49.09) of the parent ratings (CPRS) were not as low as the CTRS, and therefore there was a greater chance that ratings would show variability.

A final problem with the implementation of the study concerns the amount of time that the program was executed. It is possible that eight weeks is simply not long enough for the program to produce a change in the children's attention, behavior or handwriting. It may take 12 weeks or even half the school year for more robust effects to become apparent. For example, Davidson & Williams (2000), showed that an intervention using children with developmental coordination disorder that lasted 10 weeks did not significantly change behavior when retested at one year. Also, Doyle et al. (1995) found that motor tasks, such as handwriting, require greater effort and sustained attention in children with ADHD. The lack of significant results on the ETCH handwriting measure would seem to support this conclusion. Studies have shown that children's handwriting improves with age (Graham, Weintraub, & Berninger, 1998; Hamstra-Bletz, & Blote, 1990), especially after fourth grade, illustrating that maturation on this skill can be expected. However, no significant changes in legibility were found for any of the groups. The results of the present study suggest that no maturation effects were present, suggesting that the program was not administered for a sufficient length of time to produce treatment effects.

Besides implementation factors, setting variables may have caused artifacts and biases affecting the outcome of the data in five ways. First, biased interaction with subjects may have taken place since the researcher was directly involved with the students during the pre-testing, for the duration of the intervention, and at post-testing. It is possible that the participants in the treatment condition who were exposed to the experimenter every day developed a relationship with her. Whereas, the children in the control group would not have developed this relationship, which may have influenced posttest scores.

Second, due to informed consent, students as well as parents and teachers, were aware of who was and who was not in the treatment condition. This could have biased the participants and affected the results. For instance, since the children knew they were a part of a study, they may have had expectations which biased the post-testing on the CPT II and ETCH. Also, teachers were aware of which children were in the treatment and control groups and teachers may have had expectations about the children's behavior, which may have been biased in their posttest ratings. This could also be true of the parents.

Third, the quest to obtain more students with symptoms of ADHD led to a more sources of setting variance. For example, there were three teachers for each grade and they could have had different criteria in making their decisions about behavior, both pretest and posttest. In addition, variance was introduced because it was not possible to have the same activities in each of the classes for the children in the no treatment condition. Different schools handled this differently in order to minimize the disruption of the students, contributing to another source of setting variance.

Fourth, setting variables relating to the amount of time that the children participated in the intervention may have created a confound. For example, students in the treatment condition were unable to engage in the program for the eight weeks as planned. Due to school holidays, and other events which interfered with the schedule, one class did the handwriting exercises for 35 days while others did them for 37 days (instead of 40 days). Also, children who were absent would have missed out on the exercises, and no accounting of absences was made or included in the calculation of the data. This lack of consistency in treatment could have impacted the results of the study.

And fifth, it is also possible that the children did not take the treatment seriously. The results of the exit interview, filled out by the all children in the treatment condition, illustrated that a high percentage (79%) of the children liked the participating in the program. However, a smaller percentage agreed that they liked the handwriting exercises (73.8%) or music (67.9%). Perhaps they were glad to get out of class, but not as glad to actually do the exercises or listen to the music. Their lack of interest could have affected their scores at post-testing because they may not have applied themselves to the exercises in a way that would actually make a change. Also, the exit interview indicates that there were differences between the schools and grades in their preference for the program. Whatever the causes of these differences, it is possible that this may have affected posttest performance on the CPT II-D′ and ETCH.

The discussion so far has outlined the factors that may have led this study to an inadequate testing of the graphomotor and music program and, therefore, an inadequate test of Barkley's model of ADHD. Barkley (1997a, & 1997b) proposes that the central impairment of ADHD is behavioral inhibition, which in turn affects the attentional and motor systems. Dynamic systems theory suggests that changes in behavior can be accomplished through an interaction of an intervention which combines active participation in a goal-directed activity, and an enhanced environment (Gilfoyle et al., 1981; Kielhofner & Forsyth, 1997). It was hypothesized in the present study that through a dynamic interaction, this intervention, which combines graphomotor exercises with music, could affect changes in behavior inhibition and thereby improve the attention, behavior and handwriting of children with symptoms of ADHD. However, the discussion of confounds in the study suggests that no changes in executive function took place as a result of how this program was implemented in this experiment.

Besides the limitations already discussed there may have been aspects of the program itself which contributed to the lack of expected results. An integral part of the program is the need for the children to get in time with the beat of the music (timing) as they perform the graphomotor exercises (motor task) (Farmer, 1993). Another intervention that was cited earlier, the *Interactive Metronome* (Shaffer, et al., 2001), accomplished a similar interaction of motor task and timing, and found significant results on measures of attention and behavior. That intervention used computer monitoring to enable the subjects to clap in time with the metronome. The subjects could not progress to the next task until they had mastered the first one (Shaffer, et al., 2001). Feedback was immediate. However, in the present intervention, instant feedback and constant monitoring was not accomplished. The participants were instructed and reminded to get into the beat of the music as they were doing their graphomotor exercises. But, since this intervention was done in a classroom setting, it was not possible for the experimenter to concentrate on one individual at a time to ensure that he/she was mastering the exercises and getting into the beat of the music. After three or four days on the same lesson, some children began to get bored with the lesson and wanted to move on to a new one. Those who had not mastered the exercise or getting into the beat, had to move on with them. The expected interaction between the graphomotor exercises and music likely did not take place and could account for lack of significant results. It should be noted that the *Interactive Metronome* is an intervention that uses gross motor movements, while the program used in the present study used fine motor movements.

In addition, the exit interview revealed that fifth and sixth graders did not prefer the music. It is possible that their lack of preference could have affected their ability to get into the beat of the music, thereby limiting the effectiveness of the program.

This lack of true interaction of the music and graphomotor exercises represents a major problem with how the present experiment was designed, and also with how the intervention was designed. The program is intended to be used as a both an individual program and a classroom program. On an individual basis, under more direct supervision, this intervention may be able to accomplish its goal of combining graphomotor exercises and music, but as a classroom program using children of differing motor abilities, it is difficult to get the full effect of the intervention in only eight weeks.

In any case, the interactive effect of the graphomotor exercises and music program most likely did not take place, and so it was not able to affect the attention, behavior or handwriting of the children.

It should be noted that several significant results of the study were found. First, the correlations between the pretest parent ratings and teacher ratings were much stronger than reported by Conners (2001), with the two ratings sharing 38.4% of the variance for the female participants, and 34.3% for the males.

Second, a moderate correlation between teacher's rating and the CPT II-Index was found (16.2%).

Third, Barkley and others have suggested that the handwriting of children with ADHD is poorer than normal children. The present study supported this since the handwriting legibility of children with ADHD (89.98) was rated significantly worse on the ETCH than normals (95.60). However, this is still better than the average scores from children with borderline readability (75% - 80%) suggested by Amundson (1995).

Future Research

An examination of the design of the experiment and its effect on the testing of the program suggest that an improved design might better test the effectiveness of this program. Future study should attempt to eliminate as much of the variance as possible, and be performed for a longer period of time to give the program a chance to show its effectiveness.

Six specific changes that might better enable the program to show effectiveness are recommended. First, use an ADHD group that is not a mixture of subtypes, preferably ADHD-HI and/or ADHD-C in order to test Barkley's model of ADHD and executive function. Second, use measures that are more sensitive to the effects of the program. In one study, a strong relationship between language comprehension and fine motor test scores was found (Schwartz & Regan, 1996). These authors suggest that some elements of timing may be shared by both language and fine motor skill, which suggests that it may be more helpful to use a measure of language comprehension to measure changes from this program. Third, since the exit interview data suggests that children in lower grades enjoy the program more than older students, it might be more effective to use participants who are younger. Fourth, this program may be more effective if used exclusively by normals, or by children with motor difficulties. This would allow those who are capable of moving faster to do so, and allow those who need more time to take more time and get more benefit from the interaction of the music and graphomotor exercises together. Fifth, since handwriting legibility has been shown to be different between boys and girls (Graham, Berninger, Weintraub & Schafer, 1998), investigating gender effects would be important. And, sixth, test for the differential treatment effects of handwriting vs. handwriting and music, so that it can be determined if an interaction between music and graphomotor exercises can take place as hypothesized by the program. In the future, with improved methods and design, the effects of this program may be uncovered.

APPENDIX A

CHILD HEALTH QUESTIONNAIRE

Confidential Child Health Questionnaire (CHQ)*

Name of child	
1. Date of Birth: month: _____ day:_____ year: _____	
2. Birth Weight: _____lb. _____oz.	
3. Was your child born prematurely (too early) at less than 40 weeks of pregnancy? *How many weeks premature was your child born?* ___________	_____ yes _____ no
4. Could your child breath on his own when he was born?	_____ yes _____ no
5. Did your child need to be placed on a ventilator when he was born?	_____ yes _____no
6. Did it become necessary for the child's biological mother to take medications during pregnancy? *Which drugs?* ______________________________	_____ yes _____ no
7. Does your child have allergies to specific medications? *To what?* ____________________________________	_____yes _____ no
Has your child had any of the following?	
8. Asthma?	_____ yes _____ no
9. Frequent Sinus Infections (more than one per year)?	_____ yes _____ no
10. Frequent Ear Infections (more than four in any 12 month period)?	_____yes _____ no
11. Frequent Headaches (more than one a month)?	_____ yes _____ no
12. Meningitis?	_____ yes _____ no
13. Head Trauma?	_____yes _____ no
14. Anxiety Disorder?	_____ yes _____ no
15. Attention Deficit Disorder? *Please list any medications your child is currently taking* ____________________________________.	_____ yes _____ no
16. Conduct Disorder?	_____yes _____ no
17. Developmental Disabilities (mental retardation)?	_____ yes _____ no
18. Depression?	_____yes _____ no
19. Dyslexia?	_____yes _____ no
20. Learning Disabilities? *Which ones?* ______________________________.	_____ yes _____ no
21. Oppositional Defiant Disorder?	_____yes _____ no
23. Tourrette Syndrome? *Please list any medications your child is currently taking* ____.	_____ yes _____ no
24. Problems doing mathematics?	_____yes _____ no
25. Problems reading? *Explain:* ____________________________________.	_____yes _____ no
26. Does your child wear glasses or contacts?	_____yes _____ no

*Adapted from Family Health Questionnaire Collings, R.D. (2001). *An examination of vigilance and behavior inhibition deficit related to Attention Deficit/Hyperactivity Disorder Inattentive and Combined Types.* Unpublished doctoral dissertation, University of California at Riverside.

APPENDIX B

CONNERS' PARENT RATING SCALE-REVISED

Conners' Parent Rating Scale - Revised (S)

by C. Keith Conners, Ph.D.

Child's Name:______________________________ Gender: M F

Birthdate:____/____/____ Age:_____ School Grade:_____
Month Day Year

Parent's Name:______________________________ Today's Date:____/____/____
Month Day Year

Instructions: Below are a number of common problems that children have. Please rate each item according to your child's behavior in the last month. For each item, ask yourself, "How much of a problem has this been in the last month?", and circle the best answer for each one. If none, not at all, seldom, or very infrequently, you would circle 0. If very much true, or it occurs very often or frequently, you would circle 3. You would circle 1 or 2 for ratings in between. Please respond to each item.

	NOT TRUE AT ALL (Never, Seldom)	JUST A LITTLE TRUE (Occasionally)	PRETTY MUCH TRUE (Often, Quite a Bit)	VERY MUCH TRUE (Very Often, Very Frequent)
1. Inattentive, easily distracted	0	1	2	3
2. Angry and resentful	0	1	2	3
3. Difficulty doing or completing homework	0	1	2	3
4. Is always "on the go" or acts as if driven by a motor	0	1	2	3
5. Short attention span	0	1	2	3
6. Argues with adults	0	1	2	3
7. Fidgets with hands or feet or squirms in seat	0	1	2	3
8. Fails to complete assignments	0	1	2	3
9. Hard to control in malls or while grocery shopping	0	1	2	3
10. Messy or disorganized at home or school	0	1	2	3
11. Loses temper	0	1	2	3
12. Needs close supervision to get through assignments	0	1	2	3
13. Only attends if it is something he/she is very interested in	0	1	2	3
14. Runs about or climbs excessively in situations where it is inappropriate	0	1	2	3
15. Distractibility or attention span a problem	0	1	2	3
16. Irritable	0	1	2	3
17. Avoids, expresses reluctance about, or has difficulties engaging in tasks that require sustained mental effort (such as schoolwork or homework)	0	1	2	3
18. Restless in the "squirmy" sense	0	1	2	3
19. Gets distracted when given instructions to do something	0	1	2	3
20. Actively defies or refuses to comply with adults' requests	0	1	2	3
21. Has trouble concentrating in class	0	1	2	3
22. Has difficulty waiting in lines or awaiting turn in games or group situations	0	1	2	3
23. Leaves seat in classroom or in other situations in which remaining seated is expected	0	1	2	3
24. Deliberately does things that annoy other people	0	1	2	3
25. Does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behavior or failure to understand instructions)	0	1	2	3
26. Has difficulty playing or engaging in leisure activities quietly	0	1	2	3
27. Easily frustrated in efforts	0	1	2	3

APPENDIX C

CONNERS' TEACHER RATING SCALE - REVISED

Conners' Teacher Rating Scale - Revised (S)

by C. Keith Conners, Ph.D.

Child's Name:________________________ **Gender: M F**

Birthdate:____/____/____ **Age:**______ **School Grade:**______
Month Day Year

Teacher's Name:________________________ **Today's Date:**____/____/____
Month Day Year

Instructions: Below are a number of common problems that children have in school. Please rate each item according to how much of a problem it has been in the last month. For each item, ask yourself, "How much of a problem has this been in the last month?", and circle the best answer for each one. If none, not at all, seldom, or very infrequently, you would circle 0. If very much true, or it occurs very often or frequently, you would circle 3. You would circle 1 or 2 for ratings in between. Please respond to each item.

	NOT TRUE AT ALL (Never, Seldom)	JUST A LITTLE TRUE (Occasionally)	PRETTY MUCH TRUE (Often, Quite a Bit)	VERY MUCH TRUE (Very Often, Very Frequent)
1. Inattentive, easily distracted	0	1	2	3
2. Defiant	0	1	2	3
3. Restless in the "squirmy" sense	0	1	2	3
4. Forgets things he/she has already learned	0	1	2	3
5. Disturbs other children	0	1	2	3
6. Actively defies or refuses to comply with adults' requests	0	1	2	3
7. Is always "on the go" or acts as if driven by a motor	0	1	2	3
8. Poor in spelling	0	1	2	3
9. Cannot remain still	0	1	2	3
10. Spiteful or vindictive	0	1	2	3
11. Leaves seat in classroom or in other situations in which remaining seated is expected	0	1	2	3
12. Fidgets with hands or feet or squirms in seat	0	1	2	3
13. Not reading up to par	0	1	2	3
14. Short attention span	0	1	2	3
15. Argues with adults	0	1	2	3
16. Only pays attention to things he/she is really interested in	0	1	2	3
17. Has difficulty waiting his/her turn	0	1	2	3
18. Lacks interest in schoolwork	0	1	2	3
19. Distractibility or attention span a problem	0	1	2	3
20. Temper outbursts; explosive, unpredictable behavior	0	1	2	3
21. Runs about or climbs excessively in situations where it is inappropriate	0	1	2	3
22. Poor in arithmetic	0	1	2	3
23. Interrupts or intrudes on others (e.g., butts into others' conversations or games)	0	1	2	3
24. Has difficulty playing or engaging in leisure activities quietly	0	1	2	3
25. Fails to finish things he/she starts	0	1	2	3
26. Does not follow through on instructions and fails to finish schoolwork (not due to oppositional behavior or failure to understand instructions)	0	1	2	3
27. Excitable, impulsive	0	1	2	3
28. Restless, always up and on the go	0	1	2	3

APPENDIX D

PARENT INFORMED CONSENT

Parent Informed Consent

Study of Handwriting Movement Exercises

Your child is being asked to participate in a study designed to investigate the affect of a handwriting movement intervention on children. This study is being conducted by Lucy Heyming under the supervision of Dr. Fred Newton, professor of psychology and under the authorization of Patricia Vesley, principal of St. Catherine of Alexandria. This study has been approved by the Institutional Review Board, at California State University, San Bernardino. The university requires that you give your consent before your child may participate in this study.

Your child will be asked to participate in some classroom activities involving handwriting exercises. The task should take about 10 minutes a day to complete and will be performed during school hours. A copy of the program will be available for your inspection during regular school hours in the school office. The study will last eight weeks. Data will be collected from school records on selected participants. If your child is selected you will be asked to fill out a family health questionnaire that will take about 5 minutes to complete and a behavior questionnaire before the study and after the study, which will take about five minutes to complete each time. Your child's teacher will be asked to fill out a behavior questionnaire before and after the study also. You and your child's confidentially will be kept at all times. Your child's name will not be reported with his or her responses. All data will be reported in group form only. You may receive the
results of this study upon completion in the Spring Quarter, 2003 by contacting Professor Newton at 880-5588.

Your child's participation in this study is voluntary. You are free to withdraw your child at any time during this study without penalty. When the study is complete, you will receive statement describing the study in more detail. In order to insure the validity of the study, we ask you not to discuss this study with other parents or teachers until completion of the study.

If you have any question or concerns about this study, please feel free to contact Professor Newton at 880-5588.

By signing below, I acknowledge that I have been informed of and understand the nature and purpose of this study, and I freely consent to allow my child to participate. I also acknowledge that I am at least 18 years of age.

____

Name and grade of child:

____

Signature

____

Today's date:

APPENDIX E

TEACHER INFORMED CONSENT

Teacher Informed Consent

Study of Handwriting Movement Exercises

This study in which you are about to participate is designed to investigate the affect of a handwriting movement intervention on children. This study is being conducted by Lucy Heyming under the supervision of Dr. Fred Newton, professor of psychology and Patricia Vesley, principal of St. Catherine of Alexandria School. This study has been approved by the Institutional Review Board, at California State University, San Bernardino. The University requires that you give your consent before participating in this study.

In this study you will be asked to assess the behavior of designated students before and after the intervention, which should take approximately five minutes for each student each time. The duration of the study will be eight weeks. Your name will not be reported with your responses. All data will be reported in group form only. You may receive the results of this study upon completion in the Spring Quarter, 2003, by contacting Professor Newton at 880-5588.

Your participation in this study is totally voluntary. You are free to withdraw at any time during this study without penalty. When the study is complete, you will receive a debriefing statement explaining the study in more detail. In order to insure the validity of the study, we ask you not to discuss this study with students or parents or other teachers.

If you have any question or concerns about this study, please feel free to contact Professor Newton at 880-5588.

By signing below, I acknowledge that I have been informed of, and that I understand the nature and purpose of this study, and I freely consent to participate. I also acknowledge that I am at least 18 years of age.

____
Signature

____
Today's date

APPENDIX F

CHILD INFORMED CONSENT

Child Informed Consent

Study of Handwriting Movement Exercises

You are being asked to be in a study about handwriting and school children. Lucy Heyming is doing this study with Dr. Fred Newton, a professor of psychology at California State University, San Bernardino. Mrs. Vesley, the principal of your school, has approved it. The University needs your consent in order for you to be part of this study.

In this study, you may be asked to do some handwriting exercises during class. The task should take about 10 minutes a day. The study will last eight weeks. Your name will not be part of the information gathered, and no one will know how well you did, including your parents or teachers.

Taking part in this study is your choice. You are free to stop at any time during this study if you want to. When the study is done, you will find out more about it. In order to make sure the study is valid, we ask you not to talk about it with other students.

If you have any questions about this study, please ask your parents about them.

If you understand what the study is about and agree to take part, please check the box below.

Place a check mark here ☐ Today's date:

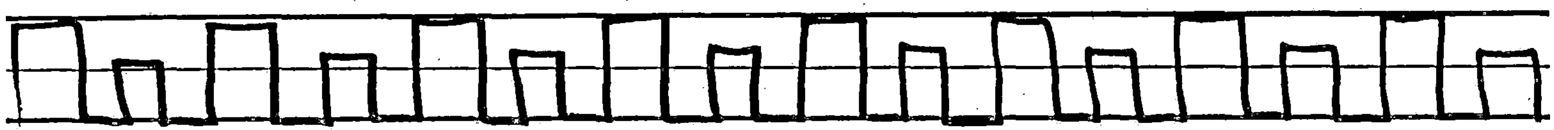
APPENDIX G

ANGLE-STRAIGHT LINE (ASL) EXERCISE

use music #3

SAMPLE OF EXERCISE #3b - CHIMNEYS SHORT AND TALL (ASL)

Have the child retrace the pattern first before reproducing it.



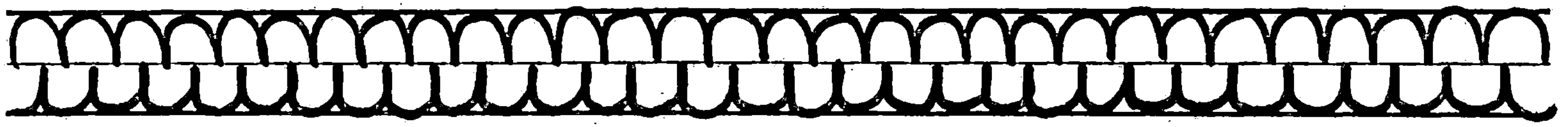
APPENDIX H

GARLAND-ARCADE-LOOP (GAL) EXERCISE

Use music #1 or #4

SAMPLE OF EXERCISE #1c - CREEPY CRAWLIES THREE (GAL)

Have the child retrace the pattern first before reproducing it.



APPENDIX I

PARENT DEBRIEFING STATEMENT

Parent Debriefing Statement

Study of Handwriting Movement Exercises

The study that your child has just completed was designed to investigate the effect of the handwriting movement program, *Training the Brain to Pay Attention the Write Way*, by Jeanette Farmer on children with deficits in attention, distractibility and hyperactivity. It is hypothesized that these exercises, a combination of handwriting movement exercises and music, will help improve children's attention in class and at home, their impulses in class and at home, and improve their handwriting.

Thank you for your participation and your child's participation. If you have any questions about the study, please feel free to contact Professor Fred Newton at (909) 880-5588. If you would like to obtain a copy of the group results of this study, please contact Professor Fred Newton in December, 2003.

APPENDIX J

CHILD DEBRIEFING STATEMENT

Child Debriefing Statement

Study of Handwriting Movement Exercises

The study that you just finished was trying to find out the affect of the handwriting movement exercises on children who have a hard time paying attention, and keeping still. It is hypothesized that these exercises, which use handwriting movement exercises and music, will help children's pay attention and keep still both at home and in class. Also, we hypothesized that it would improve their handwriting.

Thank you for your participation. If you have any questions about the study, please feel free to call Professor Fred Newton at (909) 880-5588. If you would like to obtain a copy of the group results of this study, please ask Professor Fred Newton in December, 2003.

APPENDIX K

TEACHER DEBRIEFING STATEMENT

Teacher Debriefing Statement

Study of Handwriting Movement Exercises

The study that you have just completed was designed to investigate the effect of the handwriting movement program, *Training the Brain to Pay Attention the Write Way*, by Jeanette Farmer on children with symptoms of Attention Deficit Hyperactivity Disorder. It is hypothesized that these exercises, which are a combination of handwriting movement exercises and music, will help improve both children's attention in class and at home, better control their impulses in class and at home, and improve their handwriting.

Thank you for your participation. If you have any questions about the study, please feel free to contact Lucy Heyming or Professor Fred Newton at (909) 880-5588. If you would like to obtain a copy of the group results of this study, please Professor Fred Newton at (909) 880-5588 in December, 2003.

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