ABSTRACT

Use of Auditory and Visual Stimulation to Improve Cognitive Abilities in Learning-Disabled Children

by

Ruth Olmstead

M.A., Webster University, 1997

B.A., Northern Illinois University, 1982

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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ABSTRACT

This study examined the effects of auditory and visual stimulation (AVS) on four specific cognitive abilities known to be weak in children diagnosed with learning disabilities (LDs). Learning disabilities comprise cognitive deficits in executive functioning; such deficits include working memory, encoding, visual-motor coordination, response inhibition, planning, and processing. Aside from medication, educational remediation, and classroom interventions, no specific intervention has been found to rehabilitate such cognitive weaknesses, although previous studies using AVS demonstrated enhanced academic performance in children with learning disabilities.

The Wechsler Intelligence Scale for Children-Third Edition (WISC-III) SCAD (Symbol Search, Coding, Arithmetic, and Digit Span) was administered before and after 12 biweekly, 35-minute AVS sessions. Two index scores from the SCAD profile were also assessed: Freedom from Distractability (FFD) and Processing Speed (PS). The study design was quasi-experimental with repeated measures pre- and posttreatment. Findings demonstrated that AVS produced significant changes in specific cognitive abilities as measured by the WISC-III SCAD profile. Results suggest that this technology could greatly enhance the quality of life for learning-disabled individuals who, absent appropriate intervention, are at risk for social, psychological, and a multitude of personal disappointments and life-long failures.

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CHAPTER 1

Introduction to the Study

Introduction

Children with learning disabilities (LD) make up a significant number of the population, and the diagnosis of LD appears to be increasing. For example, 783,000 children were identified with learning disorders in 1976, and by 1992-1993 the identified population exceeded 2.3 million. In 1994, these children made up approximately 50% of all placement into special education (U.S. Office of Education, 1994). Currently, 6,195,111 disabled individuals between birth and age 21 are being served under the Individuals with Disabilities Education Act (U.S. Department 1999-2000). This number is based on enrollment in public schools (pre-kindergarten through 12th grade), and translates into approximately 13.2 % of the U.S. population. These numbers include all types of disabilities and not solely those children diagnosed with learning and attentional disorders.

Some specific cognitive weaknesses of learning disabilities include information processing, short-term memory, and encoding (Conners, Atwell, Rosenquist, & Sligh, 2001; Denckla, 1983; Gross-Tsur, Shalev, Manor, & Amir; 1995; Rourke, 1993; Shapiro, Hughes, August, & Bloomquist, 1993; Tranel, Hall, Olson, & Tranel, 1987). These cognitive deficits can be lifelong, and research demonstrates that the long-term effects of LD place these individuals at a high risk for emotional and social difficulties, and can often result in antisocial behaviors and later psychological disorders (Barkley, 1990; Barkley, Guevremont, Anastopoulos, DuPaul, & Shelton, 1993; Biederman, Faraone, & Lapey, 1992; Pisecco, Wristers, Swank, Silva, & Baker, 2001; Svetaz, Ireland, & Blum, 2001; Weiss & Hechtman, 1993). Some studies suggest that individuals with learning disabilities are also at a significantly higher risk for substance abuse than non-learning-disabled individuals (Katims, Zapata, & Yin, 1996; Maag, Irwin, Reid, & Vasa, 1994; Rhodes & Janinski, 1990).

The most common treatment interventions for learning disabilities are specialized academic instruction to strengthen cognitive weaknesses, parent training, behavioral therapy, and psychostimulant medications to address comorbid behavioral problems (Barkley, 1990, 1997; Montague, Fiore, Hocutt, McKinney, & Harris, 1996). The use of stimulant medication addresses the various attentional and behavior symptoms, but gains in long-term academic achievement have not been substantiated (MTA Cooperative Group, 1999; Swanson & Hoskyn, 1998). It is unfortunate that some children cannot receive such treatment due to lack of insurance, cost of medication, difficulty with compliance, and aversion to pharmacological intervention.

With mounting evidence that individuals with learning disabilities can have a high risk of developing long-term problems such as delinquency, drug abuse, and personality disorders (Biederman et al., 1994; Pisecco, Wristers, Swank, Silva, & Baker, 2001; Taylor, 1998), as well as continuing functional deficits and psychopathology into adulthood (Cooper & Bailey, 2001; Svetaz, Ireland, & Blum, 2001; Weiss & Heichtman, 1993), it is important to look to early intervention to decrease such later life risks. This study examined the effects of auditory and visual stimulation (AVS) on children diagnosed with learning disabilities who demonstrated low and below average scores on the Wechsler Intelligence for Children-Third Edition (WISC-III; Wechsler, 1991a) SCAD profile to determine if such a treatment intervention may improve some of the cognitive weaknesses common to those diagnosed with these disorders. Null Hypotheses 1 through 6 stated that AVS would not produce significant changes in cognitive weakness of these children as measured on the four subtests of the WISC-III (Symbol Search, Coding, Arithmetic, and Digit Span) and 2 Indices (Freedom from Distractability and Processing Speed). Research questions 7 and 8 were analyzed determine if there were any relationships among the older and younger groups and the six subtest variables.

Statement of the Problem

Though some promising studies have used AVS as an intervention for learning disorders, there are no recent studies using the newest technology to address some of the core weaknesses in those individuals diagnosed with learning disabilities. An early study by Carter and Russell (1993) administered up to 80 AVS sessions over 8 weeks to students with LD, and found significant increases in scales measuring memory, reading, and spelling, as well as in overall verbal IQ scores. A later study using 15 individual photic-driven EEG neurotherapy sessions with children diagnosed with attention deficit hyperactivity disorder (ADHD), found improvements in the WISC-III Processing Speed and Freedom From Distractability indexes (Patrick, 1994). Recent studies utilizing 30 (Joyce & Siever, 2000) and 40 (Micheletti, 1998) AVS sessions at varying frequencies for the treatment of ADHD found improved standardized test scores, a decrease in problem behaviors, and overall improvement in academic performance. These studies suggest that AVS may be a viable method for enhancing cognitive functioning in children diagnosed with learning disabilities and attentional problems.

This study used auditory and visual stimulation technology, which included faster light flickering frequencies, to investigate if significant changes in cognitive abilities could occur in only 12 applied AVS sessions. Null Hypotheses 1 through 6 stated that no significant changes would occur within the six weaknesses known to children diagnosed with learning disabilities: encoding, sequencing, numerical ability, visual motor speed and accuracy, and short-term memory. Null Hypotheses 7 stated that there would be no relationship between the groups (older verses the and younger children). Null Hypothesis 8 stated there would be no correlations between the individual WISC-III subtests scores.

Background of the Problem

Learning disabilities (LD) fall under many complex definitions and have a wide variety of manifestations and theoretical causes. The current definition of learning disabilities (Hammill, 1993) suggests that their etiology involves deficits in basic cognitive functions that are developmentally related to central nervous system dysfunction. Substantial evidence supports this theory (Chase, 1996; Flowers, 1993; Galaburda, 1991; Hynde & Semrude-Clikeman, 1989), and it is commonly agreed that such deficits specifically stem from weaknesses in executive functions, including working memory, encoding, visual-motor coordination, attention and response inhibition, planning, and processing (Barkley, 1997; Denkla, 1996;

Douglas, 1972; Kaufman, 1994; Pennington & Ozonoff; 1996; Prifitera & Dersh, 1993; Welsh & Pennington, 1988).

Studies indicate a significant correlation between LD and the diagnosis of ADHD. The reported range of comorbidity for LD and ADHD range from 10% to 92% (Biederman, Faraone, Keenan, Tsuang, 1991; Decker, McIntosh, Kelly, Nicholls, & Dean, 2001; Mayes, Calhoun, & Crowell, 2000). Estimates of the prevalence of LD is 24% to 60% for math (Barkley, 1990; Lambert & Sandoval, 1980; Semrude-Clikeman et al., 1992), 15% to 50% for reading (August & Garfinkel, 1990; Barkley, 1990; Semrude-Clikeman et al., 1992), and 24% to 60% for spelling (Barkley, 1990). Given that learning disabilities are a considerably complex construct, specific diagnosis of particular areas of cognitive weakness can be difficult. Zera and Lucian (2001) proposed that many practitioners and diagnosticians of LD may not have a sufficient understanding of the neurological system to interpret and diagnose adequately. They contend that a "specific" learning disability may be an erroneous concept with regard to the underlying dynamic and recursive interactions within the neurological system. It is suggested that the wide range of comorbidity between learning disorders and these other specific disabilities (e.g., math, reading, language, etc.) is due to the extreme complexity of the neurological system to which LD is associated, and the lack of understanding regarding such neurological complexities by evaluating practioners.

The diagnosis of a learning disability involves the use of standardized testing measures such as achievement and intelligence quota (IQ) tests. The Wechsler Intelligence Scale for Children-Third Edition (Wechsler, 1991) is commonly used to assess verbal and performance IQ scores to obtain a full scale IQ score. Verbal IQ is a measure of an individual's verbal comprehensive abilities, while the performance IQ is a measure of perceptual organizational skills. Typically, a specified discrepancy between the verbal and performance IQ test scores are considered an indicator of a learning disorder (Sattler, 1988). Zera and Lucian (2001) contended that accurate diagnoses does not come about by breaking learning disabilities into isolated, component pieces as is done with subtest scores of the WISC-III. Zera and Lucian suggest that "specific" disabilities rarely exist, and that maintaining such a theory may be detrimental to the individual as academic remediation efforts generally focus only on a specific cognitive disability, as opposed to its interactions with other parts of the neurological system and the affiliated manifestations of cognitive dysfunction.

While educational remediation addresses cognitive weakness in children with LD, stimulant medication is sometimes used to decrease some of the attentional and behavior difficulties associated with learning disabilities. It is commonly agreed that stimulant medications can cause changes in the neuroendocrine systems (Barkley, Grodzinski, & DuPaul, 1992), which can have a calming effect on hyperactive behaviors and attentional difficulties. Other findings suggest that neurological dysfunction could be improved through the regulation of hyper and hypo aroused brainwave states through the use of brainwave training (Lubar et al., 1999; Lubar, Swartwood, Swartwood, & O'Donnell, 1995; Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992; Monastra et al., 1999). Investigation involving the brainwaves of those with LD/ADHD suggested faulty regulation of brainwave activity and nervous system arousal as central to the understanding of these disorders (Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, & Lytine, 1991; Lubar, 1997). Studies utilizing quantitative electroencephalography (a spectral analysis of the electrophysiological power output from a single, midline, central location) found specific neurophysiological dysfunction within the cortical and subcortical structures that serve the frontal/striatal system, and suggest that hyper and hypo arousal of such structures are indicated (Lubar et al., 1999; Lubar, Swartwood, Swartwood, & O'Donnell, 1995a; Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992; Monastra et al., 1999). Through some of these discoveries, the use of electro-encephalography (EEG) neurofeedback evolved (a method by which the brainwave activity is reflected back to the participant via computer technology) to help improve symptom control and aid in the regulation of brainwave activity. Researchers have found that EEG neurofeedback with individuals diagnosed with attentional disorders has shown an increase in the control of behavior problems that accompany learning disorders (Carter & Russell, 1981; Lubar & Lubar, 1984, 1991, 1997; Othmer & Othmer, 1992; Tansey, 1990, 1991, 1993). The current study was conducted based upon such findings, which implicate abnormal brainwave states and decreased neuronal activity in individuals with learning disorders.

Throughout their lifetime, children diagnosed with learning disabilities are not only at risk for academic underachievement, but are also found to be at risk for a number of social and psychological problems. Research has indicated that most children with LD harbor negative self-views (Svetaz, Ireland, & Blum, 2001), leading some researchers to conclude that the disruptive behaviors associated with some of that population may be due to their negative self-image (Leung & Lau, 1989; Svetaz, Ireland, & Blum, 2001). Over the course of development it is agreed that these children are also at greater risk for conduct problems, aggression, and depression (McConaughy, Mattison, & Peterson, 1994), as well as developing difficulties with peer and family relationships (Conderman, 1995). Other researchers reported that children with learning disabilities are at a higher risk for delinquency, substance abuse, and later difficulties with adult relationships, marriage, and employment (Barkley, 1990; Barkley, Fischer, Edelbrock, & Smallish, 1991; Barkley, Guevremont, Anastopoulos, DuPaul, & Shelton, 1993; Nadeau, 1995; Weiss & Heichtman, 1993). These findings illustrate the importance of investigating and implementing early assistance and treatment for these children early in their development to prevent associated difficulties in later life.

Theoretical Support of the Study

Physical exercise and maintenance of healthy living are required for optimal health and longevity; thus the importance of any form of brain rehabilitation for ongoing cognitive maintenance and enhancement should not be underestimated. Investigations with mammals have found that brain stimulation likely induces an increase in dendritic growth (Boyde; 1998; Diamond, 1988; Kolb & Whilshaw, 1990; Spinelli & Pribram, 1967). Spinelli and Pribram (1967) found that electrode stimulation of the frontal cortex in animals produced significant recovery of neurons in the visual cortex, as measured by average evoked potentials. These results revealed that some form of stimulation of the frontal cortex can affect visual input processing, and suggested a mechanism whereby this brain region can change the amount of attention paid to external stimuli. This finding may be important in the consideration of the attentional deficits found in some form of learning disabilities. The following studies examine other effects of external stimuli to the neurophysiology of the brain.

In a series of early investigations, Diamond (1988) discovered that the intensity of environmental stimulation increased dendritic growth on a neuronal level in rats, which resulted in an increase in both brain weight and density. Diamond (1988) also found evidence of molecular, synaptic, and behavior changes, which resulted in improved performance on tasks, such as maze learning and memory. Postmortem human studies later revealed that individuals exposed to a challenging environment demonstrated greater dendritic length and structural changes in the cortex (Kolb & Whishaw, 1990). Because extension in dendritic growth can be associated with enhanced cognitive abilities, these studies concluded that if an individual was afforded a stimulating and challenging environment, physiological changes could occur within the brain, resulting in enhanced cognitive functioning.

In later studies, induction into certain brainwave states has been found to increase or decrease brain activity through the "entrainment" process (Lubar, 1991; Mann, Lubar, Zimmerman, Miller, Muenchen, 1992; Othmer & Othmer, 1992; Tansey, 1990; 1991; 1993). "Entrainment" is a process that occurs when brainwave activity falls into a specific cadence or rhythm through the use of repetitive and recurrent presentation of light and sound pulses. Brainwave entrainment through the use of auditory and visual stimulation (AVS) affects electroencephalographic (EEG) output (a measure of brainwave activity), and can result in the suppression or enhancement of specific brainwave frequencies (Lubar, 1991). Studies supported evidence that changing the cerebral electrical activity associated with LD/ADHD improved symptoms and enhanced cognitive performance (Lubar, 1991; Patrick, 1994; Russell, 1997). Light or photic driven EEG neurotherapy found improved regulation of irregular or over aroused/under aroused brainwave states which affect learning and attending, yielding in increased neuroactivation (Boyde, 1998; Carter & Russell, 1993, 1994; Patrick, 1994; Siever, 2000).

More recent studies using AVS also found a reduction of behavior disorders (Joyce & Siever, 2000; Russell, 1997) and improved academic performance on standardized tests (Carter & Russell, 1993, 1994; Micheletti, 1998; Olmstead, 2000; Patrick, 1994). These findings suggest a replicable physical phenomenon that regulates brainwave activity and increases neuronal activation and dendritic growth. Such findings have significant application to a possible rehabilitative intervention of individuals diagnosed with LD and other neurological disorders. Regardless of treatment, research suggests that LD can be a risk factor for life-long social, academic, and psychological difficulties (Cooper & Bailey, 2001; Svetaz, Ireland, & Blum, 2001; Weiss & Heichtman, 1997). The risk of such life-long difficulties may be decreased if an effective non-drug intervention to address and rehabilitate the core cognitive weaknesses associated with LD is more thoroughly researched and implemented. If effective, treatment in early life may significantly improve academic performance, the psychological well being, and increase successes in the lives of many of these individuals.

Purpose

The purpose of this study was to examine the effects of AVS on specific cognitive abilities in children ages 6 through 15 previously diagnosed with learning disabilities (LD). It should be noted that children with a combined diagnoses of LD/ADHD were included, as many previous studies using similar technology for treatment intervention have used this population. Due to the limited number of available children not taking medication, children with combined LD/ADHD diagnoses were accepted, as this study is focused on specific cognitive abilities known to be weak in both populations. For inclusion into this study, all of the participants had to demonstrate low to below average scores on the SCAD profile of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III; Wechsler, 1991a). The SCAD profile comprises four subtests: Symbol Search, Coding, Arithmetic, and Digit Span. The Symbol Search and Coding subtests measure the functions of speed of information processing, visual short-term memory, and visual motor coordination and sequencing. Arithmetic and Digit Span measure number ability and short-term memory. The SCAD profile additionally yields two index scores: Freedom From Distractability (FFD), a measure of concentration, attention, and shor-term memory; and Processing Speed (PS), a measure of mental and motor speed, and the ability to plan, organize, and develop relevant strategies (Sattler, 1992).

Null Hypotheses

1: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of the speed of information processing and visual-motor coordination as measured by the Symbol Search subtest of the WISC-III.

2: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of information processing and visual-motor coordination as measured by the Coding subtest of the WISC-III.

3: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of number ability and short-term memory as measured by the Arithmetic subtest of the WISC-III.

4: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of short term memory as measured by the Digit Span subtest of the WISC-III.

5: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of the ability to attend and concentrate as measured by the Freedom From Distractability (FFD) Index of the

WISC-III.

6: Auditory and visual stimulation (AVS) would produce no significant difference (t test, $p < .05$) between the mean pre and posttest scores of overall processing speed as measured by the Processing Speed (PS) Index of the WISC-III.

7: There would be no relationship between age and WISC-III subtest scores

($p < .05$).

8: There will be no significant correlations among the dependent measures of Symbol Search, Coding, Arithmetic, Digit Span, FFD and PS of the WISC-III ($p < .05$).

Importance of the Study

The number of children diagnosed with learning disabilities appears to be on the rise. Additionally, the health care field continues to change with the emergence of managed care, and due to the subsequent reduction of services provided, it becomes imperative to find alternative, more effective, and economical methods to treat learning disorders. When used, the standard pharmacological treatment of LD is not always effective (Ahmann, Waltonen, & Olson, 1993; Gross, 1995) and can result in unwanted side effects and problems with compliance (Ahmann, Waltonen, & Olson, 1993; Greenhill, 1995). Additionally, such medications do not directly enhance cognitive weaknesses (Rapport, Denny, DuPaul, Gardener, 1994; Weiss & Heichtman, 1993); thus individuals diagnosed with learning disorders likely continue to develop social, academic, and psychological difficulties and disorders.

As there is no evidence that pharmacology or behavioral interventions rehabilitate specific cognitive weaknesses found in individuals with learning disabilities, the use of AVS may alter the course of treatment and demonstrate permanent, rehabilitative changes in specific brain functions that are central to these disorders. AVS may offer a safe, inexpensive, and short-term intervention that could result in the correction of the core symptomology defining these disorders, and assist in a decline of the comorbid social, academic, and psychological difficulties and disorders that likely develop in later life.

Definition of Terms

Attention deficit hyperactivity disorder (ADHD): A developmentally disabling disorder that is characterized by the inability to self-regulate focused attention. Individuals with hyperactivity demonstrate characteristics which include hyperactivity, impulsivity, and behavioral difficulties (*APA,* 2000).

Auditory and visual stimulation (AVS): A method using light and sound to cause the brain to change its patterning of response and hence change the looping between different cortical areas (Lubar, 1997)

Axon: The process of a neuron by which impulses travel away from the cell body, at the axon terminal to other nerve cells (Saunders, 1994).

*Biofeedback***:** Information about a body function; used in biofeedback training to gain personal control over that function (Howard, 1994).

Cerebral cortex: The thin (about 3 mm) layer of grey substance covering the surface of each cerebral hemisphere, folded into gyri that are separated by sulci. It is responsible for the higher mental functions, movement, visceral functions, perception, and behavioral reactions, and for the association and interaction of these functions (Saunders, 1994).

Dendrite: A threadlike extension of cytoplasm of a neuron which branch into tree-like processes (Saunders, 1994).

Electroencephalogram (EEG): a recording of the potentials (the electrical activity developed in a nerve cell during activity) on the skull generated by currents emanating spontaneously from nerve cells in the brain (Saunders, 1994).

Electroencephalographic (EEG) neurofeedback: A technique for modifying specific EEG frequencies and modifying the neurophysiological and neurological basis for learning and for the management of a number of neurologically based disorders (Saunders 1994).

Evoked potential: An electroencephalographic measurement of a neural impulse in response to a controlled stimulus, such as a flash of light or an audible beep (Howard, 1994

Learning: A relatively long-lasting adaptive behavioral change as a result of experience (Saunders, 1994).

Learning disability (LD): A heterogeneous group of disorders of reading, writing, mathematics, reasoning, listening, speaking, or listening, that are though to result from central nervous system dysfunction and are not due to sensory weaknesses, mental retardation, emotional disturbance, cultural differences, or insufficient instruction (The National Joint Committee for Learning Disabilities, 1991).

Neurofeedback: A technique for modifying the resonant loops (between neocortical columns of cells known as local, regional, and global resonances or EEG frequencies), and thus modifying the neurophysiological basis for learning and the management of a number of neurologically based disorders (Lubar, 1997).

Neuron: A structural and functional unit consisting of a cell body, containing a nucleus and the surrounding cytoplasm; several dendrites; and one long process (Axon), which terminates in telodendrons with terminals for receiving and transmitting nerve impulses (Saunders, 1994).

Photic stimulation: A method of brainwave stimulation and brain activation which is driven by flickering light through the optic nerve (Olmstead, 2000).

Quantitative EEG: A method of measuring brainwave activity which involves a spectral analysis of electrophysiological power output from a single, midline, central location using electrodes which are placed on the scalp (Lubar, 1997).

Synapse: The place where two neurons make electrochemical contact and transmit a nerve impulse from one neuron to another, usually by a chemical neurotransmitter released by the axon terminal of the excited or presynaptic cell (Saunders, 1994).

Visual evoked potential: In electroencephalography, changes in the evoked cortical potential (the electrical activity developed in a nerve cell during activity) when the eye is stimulated by light (Saunders, 1994).

Limitations of the Study

Since the participants in this study came from the local community, the results of the research are limited in generalizability to other populations. The sample was small, approximately 30, between the ages of 6 and 16 years, and may have not adequately represented children of all ages. Because LD comprises a multitude of disorders and a wide variety of concomitant cognitive weakness and deficits, only a small number of core cognitive abilities known to be weak in those with LD were measured.

Assumptions

It was assumed that these children were average and below average in some cognitive abilities only with regard to scores on certain subtests measuring specific cognitive areas. All children had been formally diagnosed with a form of learning disorder. Additionally, all of the scores demonstrated on the WISC-III SCAD profile were assumed to be an accurate assessment of the children's current cognitive abilities, as they were all found to have a combination of low-average and below-average scores in order to meet the criteria of the study. It should be noted that the four WISC SCAD profile subtest scores and the additional two Index scores separate or combined do not represent in any way the participants' IQ score, and represent only partial intelligence assessment.

Summary

Learning disabilities comprise deficits in executive functioning, including working memory, encoding, visual-motor coordination, response inhibition, planning, and information processing. Aside from educational remediation and the use of medication, no specific intervention may rehabilitate the specific cognitive weaknesses associated with learning disabilities. This study investigated the use of auditory and visual stimulation to enhance four cognitive weaknesses known to be common in individuals diagnosed with learning disabilities. A small device producing auditory and visual stimulation (AVS) through the use of headphones and light glasses was applied to 30 children ages 6 through 16. Twelve 35-minute AVS sessions were given twice weekly for 6 weeks. Measures using the WISC-III SCAD profile were administered pre- and post- treatment.

Chapter 2 provides an overview of the definition and etiology of learning disabilities, including specific deficits such as executive function, attention, working memory, and self-regulation. Additionally, diagnosis and assessment of LD are discussed, as well as the specific subtests used in this study. Psychosocial dysfunction resulting from learning disabilities and educational remediation are addressed. Newer methods of diagnosis and treatment involving EEG neurofeedback findings, which evolved into the use of auditory and visual stimulation treatment, are also described. Finally, theoretical justification for use of AVS for LD intervention are discussed with related studies and their findings.

CHAPTER 2

Review of the Literature

Etiology of Learning Disabilities

The most broadly accepted definition of learning disabilities is published by the National Joint Committee on Learning Disabilities (1981) and describes a heterogeneous group of disorders of listening, speaking, reading, writing, reasoning, or mathematical abilities intrinsic to the individual, and are presumed to be due to central nervous system dysfunction. Though a learning disability may occur concomitantly with other handicapping conditions or environmental influences such as cultural differences, insufficient/inappropriate instruction, or psychogenic factors, learning disorders are not considered to be a direct result of such conditions or influences (Hammill, 1993).

A substantial number of studies investigating the etiology of learning disabilities focus on the underlying cognitive and neurological processing difficulties thought to be a result of central nervous system dysfunction (Blumsack, Lewandowski, & Waterman, 1997; Duffy & McAnulty, 1985; Flowers, 1993;

Galaburda, 1991; Hynde & Semrude-Clikeman, 1989). Lewandowski (1991) reported that behavioral and/or developmental abnormalities are found in the records of children with learning disabilities or mild neurological impairment. Further findings indicated common abnormalities present during infancy, including problems with arousal, attention, activity level, alertness, and temperament. Lewandowski noted that between the ages of 6 months and 2 years, the compromised child will exhibit delays in motor milestones, neuromuscular integrity, and fine and gross motor functions. Between 2 and 4 years, such children may exhibit speech delays, articulation problems, and poor phonology. From approximately 4 to 6 years of age, problems may include perceptual-motor weakness such as paper cutting, drawing, and printing. Between 7 and 12 years, academic and learning problems are discovered, often in the form of linguistic difficulty. Lewandowski noted that these problems were typically followed or accompanied with behavioral and social skills deficits that continue into adulthood. Other studies also conclude that children with learning disabilities have significantly more neurodevelopmental problems or delays across domains such as language, motor, attention, and social behavior, than normal achievers (Blumsack, Lewandowski, Waterman, 1997; Lewandowski, 1991; Shapiro, Palmer, Wachtel, & Capute, 1983).

Comorbidity Rates of Learning Disabilities and Attentional Disorders

Researchers have found a high comorbidity rate between learning disabilities (LD) and attention deficit hyperactivity disorder (ADHD) children. Mayes, Calhoun, and Crowell (1998) found that a learning disability was present in 70% of the children diagnosed with ADHD. The diagnostic criteria for ADHD is based on a clinical evaluation, assessing if an individual demonstrates six of nine hyperactive and/or six of nine attention-deficit behaviors, for at least 6 months. The criteria includes behaviors that are maladaptive, and not consistent with the developmental level in two or more areas. These behaviors must demonstrate clinically significant impairment in social, academic, or occupational functioning, and must be evident prior to the age of 7. The three subtypes of ADHD are predominantly inattentive, predominantly hyperactive-impulsive, and a combined type (APA, 2000).

Barkley (1997) reported that 25% to 50% of ADHD children have a type of learning disability. Other estimations of children with ADHD documented a prevalence of a type of learning disability, which ranged from 15% to 50% for reading disorder (August & Garfinkel, 1990; Barkley, 1990; Lambert and Sandoval, 1980; Livingston, Dykman, & Ackerman, 1990; Semrud-Clikeman et al., 1992) to 24% to 60% for spelling (Barkley, 1990). Estimates for combined ADHD and math disability range from 24% to 60% (Barkley, 1990, Lambert & Sandoval, 1980; Semrud-Clikeman et al., 1992). Many children with learning disabilities have attention problems even if they do not meet the criteria for ADHD (Barkley, Grodzinski, & DuPaul, 1992).

Learning Disabilities and Executive Functions

Cognitive deficits, particularly impairments in executive function, are considered to be significantly linked with learning disabilities (Barkley, 1997; Denkla, 1996; Grodzinski & Diamond, 1992; Pennington, Groisser, & Welsh, 1993; Singer & Bashir, 1999). Executive functions are control processes that affect one's overall cognitive output. Typically, these processes are associated with the prefrontal cortical regions of the brain, although other regions are also involved in their deployment (Denkla, 1996). Although executive functions are defined differently across disciplines, it is generally agreed that executive functions include planning, execution, response inhibition, selective attending, setting goals, organizing, and mental set maintenance (Singer & Bashir, 1999). Other important cognitive abilities include attention and working memory, and it is agreed by most researchers that there exists a relationship between executive function and these two important cognitive abilities (Barkley, 1996b, 1997; Esslinger, 1996; Pennington, Bennetto, McAleer, & Roberts, 1996).

The literature regarding the development of executive functioning in normal children suggested that children begin to develop planning skills and mental set maintenance by the time they are approximately 2 years of age (Bruner, 1973). There is evidence to suggest that considerable neurological maturation occurs between the ages of 3 and 12 (Welsh & Pennington, 1988; Welsh, Pennington, & Grossier, 1991). By the age of 12, many aspects of measured executive function are at, or near, adult levels (Appellof & Augustine, 1986; Becker, Issac, & Hynd, 1987; Chelunu & Baer, 1986; Chelune & Thompson, 1987; Kirk & Kelly, 1986; Passler, Issac, & Hynd, 1985).

Children with deficits in executive function may not fully develop the essential abilities to interact effectively and productively within their environment (Marlow, 2000). In childhood, they may demonstrate a wide range of cognitive, social, and academic disorders. In adolescence and adulthood, they tend to encounter significantly greater difficulty living independently and productively as they approach everyday tasks (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999). The role of executive functioning is important in learning, and many researchers agree that the level of executive functioning ability in regard to children’s cognitive skills is found to be a good predictor of academic performance (Gathercole, & Pickering, 2000a; Gathercole & Pickering, 2000b; Letho, 1995; Lorsbach, Wilson, & Reimer, 1996; McLean & Hitch, 1999; Ozonoff & Jensen, 1999; Russell, Jarrold, & Henry, 1996; Swanson, 1993; Swanson, 1999; Swanson, Ashbaker, & Lee, 1996).

Attention, Working Memory, Executive Function, and the Frontal Lobes

Deficits in attention, working memory, and executive functions have a direct effect on learning (Denkla, 1996a, 1996b). Individuals with executive problems and / or attentional deficits may encompass another category of learning disabilities in and of themselves, as these abilities are generally considered to be mediated by the frontal lobe/frontal systems (Barkley, 1997; Denkla, 1996a, Mesulam, 1990; Stuss, 1992) and are interconnected to other brain functions. It is therefore possible that all cognitive systems are sensitive to frontal lobe pathology (Lazar & Yitzchak, 1998; Mesulam, 1990). Many theorists believe the constructs of attention, working memory, and executive functioning and their roles in behavior have overlapping features (Barkley, 1997; Denkla, 1996a; Mesulam, 1990), and it may be difficult to differentiate these three cognitive abilities as they work in accordance with each other. Cherkes-Julkowski, Sharp, and Stolzenberg, (1997) noted that though attention and memory are needed to create complex thinking, they are very susceptible to weakness when cognitive functioning is disrupted. According to Cherkes-Julkowski, Sharp, and Stolzenberg (1997), executive functioning specifically affects the direction and control of the management and association of information. These researchers suggested that, likewise, cognition cannot occur without an unimpaired attentional and working memory system.

Attention and Learning Disabilities

Some clinicians and investigators who work with children consider attention to be the underlying basis of most cognitive and neuropsychological functions (Cooley & Morris, 1990). Researchers agree that the ability to attend is crucial to learning (Denkla, 1996a, 1996b; Cherkes-Julkowski, Sharp, & Stolzenberg, 1997). With regard to reading, the attentional system helps to make connections between the written word and the reader's understanding (Cherkes-Julkowski et al., 1997). Cherkes-Julkowski et al. propose that controlled attention is necessary for written expression as the writer must significantly draw on the attentional resources as he or she balances the lower-level (i.e., use of pencil in forming letters) and higher-level processes (i.e., the forming of concepts and ideas). In regard to arithmetic, these researchers suggested that the attentional system has a key role in facilitating performance, and noted that sufficient attention is necessary, for example, to support the memorization of math facts and formulas and to track mental calculations.

Researchers have agreed that attention works in accord with working memory and executive functioning (Barkley, 1996b; Cherkes-Julkowski et al., 1997); thus, the ability to attend occurs within the context of other cognitive processes. Accordingly, attentional weaknesses can subsequently result in widespread cognitive difficulties (Cherkes-Julkowski, Sharp, & Stolzenberg, 1997; Denkla, 1996a, 1996b).

Working Memory and Learning Disabilities

Working memory (WM) is defined as a processing resource of limited capacity, which involves the storing and preservation of information, while simultaneously processing the same or other information (Cantor & Engle, 1993; Just & Carpenter, 1992; Salthouse, 1996). Working memory has been linked with both executive functioning (Barkley, 1997; Swanson, 1994) and attention (Cherkes-Julkowski et al., 1997). According to Roberts and Pennington (1996), working memory (WM) is "the ability to maintain and manipulate short-term information needed for generating upcoming action" (p.105). All forms of communication are believed to pass through the working memory system (Cherkes-Julkowski et al., 1997).

Several studies have explored the differences in children with and without learning disabilities on measures of reading, writing, spelling, and other cognitive functions, and suggested that learning difficulties are caused by weaknesses in working memory (Siegel & Ryan, 1989; Swanson, 1993a, 1993b). Working memory difficulties have also been implicated in reading disabilities (O`Shaugnessy & Swanson, 1998; Shankweiler & Crain, 1986; Swanson, 1994; Torgesen, 1996), writing difficulties, and problems with arithmetic (Cherkes-Julkowski et al., 1997; Swanson & Sachse-Lee, 2001).

Self-Regulation and Learning Disabilities

Self-regulation is a term sometimes subsumed under the canopy of executive functions (Denkla, 1996; Denkla & Reader, 1993; Hayes, Gifford, & Ruckstuhl, 1996). Self-regulation refers to a set of behaviors that can be adapted to guide, monitor, and direct the success of an individual's performance. Students are expected to self-regulate and maintain specific behaviors and direct interactions within the learning environment to ensure success. Self-regulation is seen in how well students get ready for learning, stay on task, and alter their approaches to problem solving (Singer & Bashir, 1999). According to Barkley (1997), both executive function and self-regulation are the primary features of metacognition. Others believe that both executive function and self-regulatory processes are the core of cognitive, linguistic, behavioral, and effective control, which are all fundamental to learning and academic success (Singer & Bashir, 1999).

Visual-Spatial and Information Processing Abilities in Learning Disabilities

Many studies suggest that individuals with learning disabilities have difficulties on tasks involving the processing of visual-spatial information, and thus most criteria for subtyping children with learning disabilities included at least one category for individuals with problems in the visuospatial domain (Boder, 1970; Leton, Miyamoto, & Ryckman, 1987; Lyon & Watson, 1981; Pennington, 1991; Satz & Morris, 1981). The nonverbal learning disability syndrome defined by Rourke (1989) includes difficulty with processing visuospatial material as a core element. Other research has found group differences in the rate (Bjaalid, Hoien, & Lundberg, 1993; Bryant, McIntyre, Murray, & Blackwell, 1983; Eliason & Richman, 1987; Martos, 1995) and capacity (Swanson, 1981) of visual information processing abilities. Weiler et al. (2000) noted that on a task of visual filtering sensitive to information processing speed, children with learning disabilities were specifically identified by a disproportionate weakness to processing load and speed than non-learning-disabled peers in visual filtering tasks (serial searches on tests requiring serial search, parallel search, decision, and response). A study by Weiler, Bernstein, Bellinger, and Waber (2000) found that weaknesses on measures of Processing Speed appear to be characteristic of learning-disabled children in general. With regard to the behavioral manifestations of children diagnosed with specific attention deficits, Weiler et al. (2000) theorized that vulnerability to processing load (including weaknesses in planing ability, organization, relevant strategy development, and poor motor control) may be a core weakness of many of the behavioral manifestations of attention deficit disorders.

Arithmetic and Learning Disabilities

According to Rourke and Conway (1997), mathematical reasoning is one aspect of general concept formation and problem-solving skills required for successful learning. Rourke and Conway (1997) suggest that a distinction can be made between brain behavior connections relevant to successful acquisition of arithmetic skills, and those that depend on learned performance.

Many studies conclude that the defining features of arithmetic disability are difficulties with counting procedures and deficits in memory-based processes used to solve arithmetic problems (Geary & Brown, 1991; Jordan & Montani, 1997). Additionally, weaknesses in attention significantly affect arithmetic computation skills, which likely places children diagnosed with attentional disorders at risk for arithmetic calculation deficits and the ability to master abstract symbol systems, particularly in the acquisition of basic math skills (Marshall, Hynde, Handwerk, & Hall, 1997; Marshall, Schafer, O’Donnell, Elliott, & Handwerk, 2000).

Diagnoses of Learning Disabilities

The assessment of learning disabilities typically uses a battery of tests to identify the physical, emotional, and intellectual characteristics of an individual (Searls, 1997). Most agree that the central component in all definitions of LD involve difficulties in developing skills in reading, writing, listening, speaking, reasoning, spelling, and arithmetic (National Joint Committee for Learning Disabilities,1981). Weaknesses in these abilities are often generalized as poor information processing (Groth-Marnat, 1997). The primary goal in the assessment of learning disabilities is to identify strengths and weaknesses in which to better recommend appropriate academic placement and remediation (Groth-Marnat, 1997). The Wechsler Intelligence Scales (Wechsler, 1991a) are typically considered essential as a means to identify and measure an individual's overall level of cognitive functioning and specific strengths and weaknesses. Though other standardized tests may document a particular cognitive deficit, according to Public Law 94-142 (Federal Register, December 29, 1977, p. 65083, 121a.5), a diagnosis of LD should only be made after determining that a discrepancy exists between achievement and intellectual ability in one or more expressive or receptive skills, such as reading, written expression, listening and reading comprehension, or mathematics (U.S. Office of Education, 2001).

The Wechsler Scales

There has been much effort in searching for a specific Wechsler Scale profile that is unique to the learning-disabled population. An early review of 20 research studies from 1952 to 1967 by Huelsman (1970) of the Wechsler Intelligence Scales for Children (WISC) subtest scores of reading disabled children found low scores in the Arithmetic, Coding, Information, and Digit Span subtests. This subtest grouping was labeled the "WISC syndrome for disabled readers." Of these 20 studies, Huelsman found that 100% demonstrated low Arithmetic subtests scores, 95% demonstrated low Coding subtests scores, 80% reported low scores on Information, and 60% reported low scores on Digit Span.

Later, Searles (1972) reviewed 33 WISC and reading disability studies finding percentages similar to Huelsman, and concluded that the WISC disabled-reader syndrome was well researched in the literature. Rugel (1974) investigated 25 WISC studies and compared scores when grouped into Bannatynes categories (1968). The Bannatyne categories consisted of groups of subtests that had more psychological meaning than the Verbal and Performance Scales of the WISC. The first group consisted of a Spatial category consisting of Comprehension, Similarities, and Object Assembly subtests. The second category was labeled the Conceptual category which consisted of the Comprehension, Similarities, and Vocabulary subtests, and the third was the Sequential category comprising Digit Span, Picture Arrangement, and Coding. Bannatyne (1968) suggested that the scores, when categorized, provided much more information regarding a child's deficit area. Bannatyne (1968) noted that children diagnosed with dyslexia had higher Spacial scores (sum of scaled scores for each subtest in a category) and lower Sequential scores, with Conceptual scores falling in the middle. Later, a fourth category was added called Acquired Knowledge, which consisted of Information, Arithmetic, and Vocabulary. Bannatyne's (1968) categories were based on research findings in literature and his own work.

Rugel's study (1974) confirmed the pattern Bannatyne (1968) found with dyslexic individuals of Spacial > Conceptual > Sequential. When individual and subtest scores of normals and readers with disabilities in 11 populations were compared, disabled readers scored significantly lower on these four subtests (Arithmetic, Coding, Information, and Digit Span) which became known by the 1980s as the ACID profile. Rugel credited the disabled-readers' low Sequential category rank to weaknesses in attention and short-term memory processes, and recommended replacing Picture Arrangement with Arithmetic.

When the WISC-R was first published (1974), the ACID profile was generally accepted as a predictor of the reading disabled due to the compiled evidence of studies conducted over 25 years (Bush & Mattson, 1973; Frommelt, 1964; Fuller & Friedrich, 1974, 1975; Karlsen, 1955; Levine & Fuller, 1972; McGraw, 1966; Robeck, 1964). Later, Sattler (1988) inspected 30 WISC and WISC-R studies of children with reading and learning disabilities, and provided a rank order from highest to lowest in which the average subtest scores fell. Last ranked was Information, followed by Arithmetic, Digit Span, and Coding. Profile analysis found the ACID group to be the most difficult of all subtests.

The Wechsler SCAD Profile

When the WISC-III was published by David Wechsler in 1991, Prifitera and Dersh (1993) demonstrated the occurrence of various subtests patterns with a sample of 99 LD children, a sample of 65 children with ADHD, and the standardized sample of the WISC-III. Findings demonstrated the lowest subtest scores for both ADHD and LD group were obtained in the Symbol Search, Coding, Arithmetic, and Digit Span subtests (SCAD). The Information subtests scores were in the middle of the subtest ranking, so the ACID pattern was replaced with the SCAD pattern in these samples. Both clinical groups demonstrated the pattern that Bannatyne found in the WISC-R: Spacial > Conceptual > Sequential. Since that study, other studies have found these subtests scores to be significantly lower for LD/ADHD children when compared to the average score of 10 (Newby, Recht, Caldwell, & Schaefer, 1993; Snow & Sapp, 2000; Ward, Ward, Hatt, Young, & Mollner, 1995). Based on findings by Newby, Recht, Caldwell, and Schaefer (1993), it was suggested that the fourth factor score, Processing Speed (which links the new Symbol Search subtest with Coding) may be helpful in understanding reading disabilities, as many researchers suggest that weakness in speed, and language and verbal fluidity, are important in understanding reading disorders.

Descriptions of the SCAD Profile

The SCAD profile comprised the Symbol Search, Coding, Arithmetic, and Digit Span subtests. Prifitera and Dersh (1993) incorporated these four subtests that together comprise the Freedom for Distractability and Processing Speed indices.

The WISC-III subtest Symbol Search is designed to be a test of information processing speed, planning, encoding information, in preparation for further processing, visual-motor coordination, and learning ability (Groth-Marnat, 1997). This test is suggested to pair well with the Coding subtests they both conceptually measure similar areas, as is more formally specified by a relatively high .53 correlation between the two subtests.

The WISC-III Coding subtest is a measure of speed of information processing and or learning, rote learning, sequencing, and visuo-motor abilities (Lezak, 1995; Reitan & Wolfson, 1992). The combined Coding and Symbol Search subtests scores yield the Processing Speed (PS) Index score.

The WISC-III subtest Arithmetic is a measure of computational skill, auditory memory, sequencing ability, numerical reasoning and speed of numerical manipulation, and attention and concentration (Groth-Marnat, 1997).

Digit Span is a subtest that is considered to be a test of short-term memory and attention (Wechsler, 1991). Digit Span is a two-part test consisting of Digits Forward and Digits Backward. Digits Forward is a simpler task requiring rote memory which instructs the individual to correctly take in the information which requires attention and encoding (Groth-Marnat, 1997). Digits Backward is a more complex task requiring that one accurately recall, sequence, and verbalize the information. Digits backward requires the participant to hold the memory of the spoken numbers longer, and also transform the sequence of numbers and transform it prior to making a restatement (Groth-Marnat, 1997). Individuals who cannot receive and hold the information correctly may have difficulties during this first part if they have short-term memory weakness, as they cannot retain the memory trace long enough. Digit Span is one of the subtests most sensitive to brain damage, mental retardation, and learning disabilities (Lezak, 1995; Mishra, Ferguson, & King, 1985). The combination of the Arithmetic and Digit Span subtests yield a Freedom From Distractability Index score. It is a measure of an individual's ability to attend and concentrate (Groth- Marnat, 1997).

The SCAD index has been found to have validity in identifying groups of children with learning disabilities (Hatt, Young, & Mollner, 1995; Prifitera & Dersh, 1993), LD and ADHD (Kaufman, 1994; Mayes, Calhoun, & Crowell, 1998), and ADHD (Snow & Sapp, 2000).

Learning Disabilities and Psychosocial Functioning

There is debate regarding whether psychosocial problems should be more prominent in the definitions of learning disabilities (Kavale & Forness, 1996), as there is an increasing body of clinical research suggesting that those with LD also exhibit difficulties with psychosocial functioning (Cosden, 2002; Lund & Merrell, 2001). Research findings linking learning disabilities and problem behaviors are fairly consistent. Many studies reported higher parent-teacher ratings of aggressive-disruptive, delinquent-antisocial, and/or hyperactive-inattentive behavior in children with LD in normative samples (Lund & Merrell, 2001; McConaughy & Ritter, 1985; Williams, Gridley, & Fitzhugh-Bell, 1992) and those without LD (Epstein, Cullinan, & Bursuck, 1985; Maag & Reid, 1994; McConaughy, Mattison, & Peterson, 1994). Issues with self-regulatory behaviors and social interaction and perception may co-exist, but by themselves do not constitute a learning disability. Though the direction of the relationship between LD and psychosocial dysfunction is unestablished, one theory is that LD is a result of a core emotional disturbance (Cobert, Newman, Ney, & Young, 1982; Goldstein & Dundon, 1986; Goldstein, Paul, & Sanfilippo-Cohn, 1985; Stott, 1981). This concept suggests that learning difficulties arise from unconscious blocks (Spreen, 1989) or negative interactions with instructors, unrealistic parental demands, or undiagnosed emotional disturbances which interfere with learning (Rourke & Fuerst, 1991). Other researchers support this view (Brumback & Stanton, 1983), and report that depression accentuates reading difficulties in children. Goldstein and colleagues (Goldstein & Dundon, 1986; Goldstein, Paul, & Sanfilippo-Cohn, 1985) also suggested that some children may have underlying depression, which manifests in cognitive weakness, which results in poor achievement. Though LD cannot result form serious emotional disturbance by definition (Hammill, 1993), the two issues can co-occur.

A countertheory is that repeated academic failure in LD children results in psychosocial maladjustment, poor socialization skills and interpersonal relationships, and internalizing and externalizing or disruptive behaviors (Rutter, Tizard, & Whitmore, 1970). Children with LD are more likely to be rejected and are less likely to be accepted or popular (Conderman, 1995; Nabuzoka & Smith, 1993; Ochoa & Palmer, 1991; Ochoa & Olivarez, 1995). Additionally, a meta-analysis (Kavale & Forness, 1996) found that children with LD tend to be less socially competent that their non LD peers. Social competence or appropriate use of social skills include behaviors such as cooperation with others, exhibiting self control, initiating and responding to social situations, as well as behaviors which facilitate, establish, and maintain friendships (Tur-Kaspa & Bryan, 1995).

Interventions For Learning Disabilities

There is no specific treatment for learning disabilities with the exception of remediation and specialized intervention to improve specific cognitive weaknesses. Instructional programs to aid with remediation are designed to help children with learning disabilities to develop problem solving skills, mnemonic strategies, and good study habits (Sattler, 1988). Other treatment approaches address the behavioral problems that often coexist, using cognitive behavioral therapy, family training programs, parent training, and medication to specifically address inattention, hyperactivity, and impulsivity in those diagnosed with ADHD (Swanson & Hoskyn, 1998). In a recent meta-analysis of experimental treatment outcomes, results supported the pervasive influence of cognitive strategy and direct instruction models for remediation of the academic difficulties of children with LD (Swanson & Hoskyn, 1998).

Relaxation and Biofeedback as Intervention

Several studies examined the effects of relaxation therapy for students with learning disorders (Amerikaner & Summerlin, 1982; Carter & Russell, 1985; Moltane, 1987; Omizo & Omizo, 1987a, 1988; Omizo, & Williams, 1982; Zieffle & Romney, 1985). All seven of these early studies were similar in their approaches and outcomes, which included relaxation instruction of children with LD to be calmer, more relaxed, and in control of their behaviors at home and in school. Some of these early studies used biofeedback relaxation procedures (Carter & Russell, 1985; Omizo & Williams, 1982) rather than group counseling in relaxation. Regardless, all studies demonstrated significant findings for the relaxation over the no treatment control conditions. Such positive findings appear to offer implications for the use of different types of relaxation therapy for students with LD who may appear to benefit such training.

EEG Neurofeedback as Intervention

Relaxation techniques with biofeedback devices eventually evolved into the use of encephalographic (EEG) neurofeedback to measure brainwave activity and aid in relaxation training. The earlier biofeedback devices would measure, record, and “feed back” specific information about a body function, such as temperature, rate of heart beats, or muscle tension, to assist in gaining personal control over that function (Howard, 1994). The method of recording the electrical activity of the brain, called potentials, is achieved through the placement of tiny pads at various areas of the head while relaxing. These pads measure the correspondence between intercranial brainwave currents and the resulting voltages. The frequency bands of brainwave activity measured using EEG are broken down into four categories identified by the Greek letters beta, alpha, theta, and delta. Beta waves include brainwave frequencies measured at speeds approximately from 12 hertz (Hz), or cycles per second, to 35 Hz, and are associated with peak performance, anxiety, and active and external attention. Alpha frequencies range approximately from 8 to 12 Hz, and are associated with relaxation and passive attention. Theta brainwave states range approximately from 4 to 7 Hz, and correlate with deep relaxation and inward focus. Delta states are associated with sleep, and range approximately from 0.5 Hz to 3 Hz

In using EEG neurofeedback to measure brainwave activity, specific frequencies can indicate a number of findings. The earliest studies of children with LD/ADHD indicated brainwave irregularities as demonstrated by under-aroused activity in some LD/ADHD groups and over-aroused activity in other LD/ADHD groups (Lubar & Shouse, 1976; Winkler, Dixon, & Parker, 1970). A normal EEG pattern is defined by the absence of specific abnormal brainwave patterns. An EEG is considered abnormal if it contains abnormal components regardless of whether or not it also contains normal components. Most abnormal EEG patterns are indicative of abnormal brain functioning, though abnormal patterns can occur in participants not showing evidence of brain disorder (Tansey, 1990). These early findings suggested that the EEG neurofeedback normalized brainwave patterns and improved achievement and academic scores.

Later the focus using EEG neurofeedback was on producing and sustaining brainwave states that were found to be highly conductive to concentration or learning new material. Cunningham and Murphy (1981) reported improved reading and math scores as well as increases in self-control in ADHD children following EEG neurofeedback training. Lubar (1991) demonstrated significant improvement in overall academic performance in learning-disabled (LD) students using EEG neurofeedback. Additional studies by Tansey (1990) and Carter and Russell (1981) investigated the effects of neurofeedback training on boys with LD, and noted significant gains in intelligence quota (IQ) scores. All of these studies have found that brainwave training within higher or lower arousal states, depending upon the target symptoms, demonstrated increases in overall cognitive abilities and intelligence quota (IQ) scores, as well as a lessening of impulsive and negative behaviors.

Current studies using EEG neurofeedback are consistent in identifying differences with regards to brainwave activity in LD/ADHD participants, but there is little agreement in locating the primary nature of the abnormalities (Rosenfeld, Reinhart, & Srivastava, 1997; Tannock, 1998). Some EEG findings support the theory that the frontal lobe is linked to concentration, as demonstrated by increased slow brainwave or theta activity in the frontal lobe region (Chabot & Serfontein, 1996; Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992). Other studies have reported decreased delta and/or increased beta activity, particularly within the left hemisphere, suggesting abnormal cerebral activity (Lubar, 1991, 1997). These findings raise contradictory implications regarding potential brainwave under arousal in some LD/ADHD groups and over arousal in other ADHD groups. However contradictory, these EEG neurofeedback studies are important predecessors of the current proposed study as this technique not only aids in modifying specific EEG brainwave frequencies, but also is theorized to assist in affecting and altering the neurophysiological basis for learning.

Auditory and Visual Stimulation as Intervention

Auditory and visual stimulation (AVS) is a method of brain stimulation and brainwave “entrainment” that is applied through the ears and optic nerves by means of headphones and specially designed glasses inset with white light-emitting diodes (LEDs). These lights flash at predetermined frequencies, and are coupled with binaural tones that are received by the individual through headphones. The auditory and visual stimulation are typically synchronized with each other, but can be varied depending on the treatment protocol or desired effect. The light emitting from the glasses and rate of the flickering affect the brain through the optic nerve, and cause the brainwaves to "entrain" or match the rate of flickering to a desired frequency, depending on the preferred outcome. The external flicker of light at specific frequencies have been found to induce the brainwave activity to fall into specific frequencies by becoming entrained or synchronized (Carter & Russell, 1993; Pigeau & Frame, 1992; Timmermann, Lubar, Rasey, & Frederick, 1998). The method by which this "entrainment" occurs is known as Frequency Following Response (FFR). Unlike EEG biofeedback where the object is for the user to deliberately try to calm or train brainwave activity, AVS induced "entrainment" occurs directly in the brain without any conscious effort. The Frequency Following Response is also known as the "flicker phenomenon" because of the brain's ability to reproduce or synchronize with the same rhythm as the external flashing light (Carter & Russell, 1993; Timmermann, Lubar, Rasey, & Frederick, 1998). Some findings demonstrate that not only does the area in the brain associated with sight become synchronized with the external flickering lights, but the entire cortex of the brain demonstrates changes toward the same frequency of the flashing lights (Carter & Russell, 1993; Kumano et al., 1997; Timmermann, Lubar, Rasey, & Frederick, 1998).

Because induction into certain brainwave states has been found to increase or decrease brain activity through the entrainment process (Carter & Russell, 1993; Pigeau & Frame, 1992; Timmermann, Lubar, Rasey, & Frederick, 1998), the implications of using AVS as treatment with children has been explored. Hyperactive behaviors and feelings of anxiety for example, have been found to decrease due to the reduction of high-arousal brainwave states (Rossiter & LaVaque, 1995). Other studies suggested that the application of auditory and visual stimulation may increase cognitive processes and enhance academic performance as demonstrated on standardized testing (Carter & Russell, 1981; 1993; 1994; 1995; Micheletti, 1998; Olmstead, 2001; Patrick, 1994). A more recent study demonstrated improved behavior including impulsivity in ADHD children (Joyce & Siever, 2000).

Theoretical Justification of Auditory and Visual Stimulation

Few research studies have been conducted on the efficacy of AVS for the treatment of learning disorders. Much of the early research had been done by Carter and Russell (1993, 1994, 1995), who examined changes in test performance in children with learning disabilities using brainwave entrainment and auditory and visual stimulation. Carter and Russell (1993) conducted a pilot study using AVS and measured changes in academic performance and behavioral functioning of 26 boys with learning disabilities between the ages of 8 and 12 years. All participants were administered the Peabody Picture Vocabulary Test (PPVT-R; Dunn & Dunn, 1981) to measure Verbal IQ, the Raven Colored Progressive Matrices (Raven's; Raven, Court, & Raven, 1986) to measure nonverbal IQ, the Auditory Sequencing Memory subtest of the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy, & Kirk, 1968), the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1991), and the Wide Range Achievement Test-Revised (WRAT-R; Jastak & Wilkinson, 1984). In addition, teachers and parents completed the Burk's Behavior Rating Scale (Burks, 1968) on each youth. Tests were administered one week prior to beginning AVS treatment, and during the week following cessation of AVS treatment. Participants received from 18 to 40 twenty-five-minute AVS sessions within a 6-week period. Significant findings were demonstrated on four of six variables; although the PPVT did not show significant increases in IQ, the Raven Coloured Progressive Matrices did show a significant increase in IQ ($P < .05$). The ITPA auditory sequential memory subtest scores showed significant improvement, as did the WRAT-R scores for reading and spelling ($p < .01$). Behavior changes noted by teachers and parents demonstrated some improvement in academic interest and attention. Teachers reported that students appeared less anxious, more self-contained, and demonstrated more anger control and improved coordination and intellectual pursuits. Parents reported more compliance from children and less impulsive behaviors.

A later study by Carter and Russell (1994) demonstrated the increase in Verbal IQ of 4.30 points in the experimental group after 20 sessions of AVS, and an increase of 9.20 points after 40 AVS sessions, which were significantly greater than the changes demonstrated in the placebo and control groups. In a related study, Patrick (1994) used 15 sessions of EEG driven AVS with 25 children with ADHD. A quasi-experimental waiting control group design was used with repeated psychometric tests which comprised of the WISC-III, Raven Progressive Matrices (RPM), Wechsler Individual Achievement Test (WIAT; Psychological Corporation, 1992), Achenbach Child Behavioral Checklist and Profiles (CBCL-P; Achenbach & Edelbrock; 1986a), the Test of Variables of Attention (TOVA; Leark, Dupuy, Greenberg, Corman, & Kindschi, 1996), and two separate EEG measures. Results revealed highly significant EEG changes and test score changes. Experimental participants made gains in controlling impulsivity as evident in WISC-III Processing Speed scale scores, which demonstrated 81% improvement. TOVA fourth quarter errors of commission showed 95% improvement, and CBCL-P scores found that 69% of parent ratings improved and 72% of child ratings improved. Significant gains in attention were evidenced by WISC-III Freedom From Distractability scales which demonstrated an 81% improvement.

A more in depth study dissertation demonstrated similar cognitive and behavioral changes. Micheletti (1998) compared four treatment groups of 99 ADHD children ranging from 7 to 13 years of age. The treatment groups consisted of an AVS Group, an AVS and Stimulant Medication Group, a Stimulant Medication Group, and a Self-Selected Comparison Group. All groups were tested off medication to evaluate differences at baseline. Cognitive function was evaluated using achievement tests from the Wide Range Achievement Test-Revised (WRAT-R), the Peabody Picture Vocabulary Test (PPVT), and the Raven Progressive Matrices (Raven's). Behavioral changes were noted using the Intermediate Visual and Auditory (IVA; Sanford, 1995) and the Attention Deficit Disorder Evaluation Scale (ADDES; McCarney, 1995). The study also evaluated the effectiveness of the stimulant medication (Ritalin and Adderall) and the efficacy of combining AVS and medication. Both the AVS and the AVS/Stimulant Medication Group demonstrated significant statistical cognitive and behavioral changes. The AVS training Group demonstrated statistical changes 55.6% of the time. The AVS/Stimulant Group demonstrated changes 88.9% of the time. The Stimulant Only Group demonstrated less change (33.0% of the time) when compared to the AVS and AVS/Stimulant Groups. The Self Selected Comparison Group indicated no statistical change on cognitive or behavioral dependent measures over time.

Woodbury (1996) examined the effectiveness of AVS to promote sensory integration in individuals with autism. Sensory integration is the organization of sensory input for use which may be a perception of the body or external stimulus, an adaptive response, a learning process or the development of some neural function. According to Woodbury (1996), sensory integration promotes many aspects of the nervous system in working together so one can interact effectively with the environment and experience appropriate satisfaction.

Woodbury (1996) theorized that AVS would be effective in facilitating the learning capacity of autistic children by reducing the high state of arousal, resulting in increased time on tasks and a decrease in problem behavior. Woodbury's study extended the work of Ayres (1972, 1974, 1979), who theorized that the brains of those with autism are incapable of registering, modulating, or integrating sensations, suggesting that auditory and visual inputs are ignored more than other types of sensory stimuli. Woodbury's study (1996) indicated that AVS had positively impacted the behaviors of the autistic children by increasing on-task behaviors, facilitating completion of tasks, reducing inattention, and decreasing problem behaviors and impulsivity. It was also noted that higher functioning participants seemed to benefit more from AVS than lower functioning participants, perhaps due to the more severe abnormality in brain physiology or their willingness to wear the technology on a consistent basis.

AVS as a Substitute for Stimulant Medication

A pilot study investigated the efficacy of AVS in decreasing stimulant medication intake and ADHD symptoms (Olmstead, 2000) and demonstrated moderate to significant reduction in negative behavioral symptoms according to ADHD diagnostic criteria checklists and a significant reduction of medication intake. The study consisted of 65 participants who met the Diagnostic and Statistical Manual of Mental Disorders - Fourth Edition Text Revision (DSM-IV R: APA, 1994) criteria diagnosis of ADHD. Twenty-five of the participants were on stimulant medication when beginning AVS treatment. Results demonstrated that 68% of the participants noted moderate to significant reduction in negative behavioral symptoms. A chi-square test demonstrated a significant difference from the 32% who noted no reduction in symptoms. The significant effectiveness of AVS on those participants taking stimulant medication was concluded due to decrease in medication intake as correlated with the reduction of ADHD symptoms. Of the 25 participants taking stimulant medication prior to beginning AVS treatment, 76% of the participants were able to reduce or completely discontinue medication and 24% did not. Though this study did not conduct a formal follow up to measure sustained results, these findings suggested that an AVS treatment program resulted in significant reduction in ADHD symptoms and may be a viable non-drug approach to treating this disorder.

Brainwaves and Learning with AVS

Various areas of the brain must communicate with each other to establish the basis of the assimilation of sensory information, sensorimotor coordination, and other brain functions that are necessary for learning, memory, information processing, behavior, and perception (Mitner, Braun, Arnold, Witte, & Taub, 1999). Hebb (1949) theorized that such communication occurs through the formation and connection of cells whose synaptic linkages are strengthened as a result of the synchronous firing of activated cells. It has been only since the development of technologies such as EEG to demonstrate its existence that Hebb's concept has validity. Studies have demonstrated that faster EEG activity in the gamma range (20-70Hz) heightens during, and may be associated with, the formation of ideas and memory, linguistic processing and other abilities and behavioral functions (Singer, 1990; Singer & Grey, 1995). Miltner et al. (1999) demonstrated that increased gamma band activity was not only linked to associative learning, but they found that gamma band coherence also increases between regions of the brain that are receptive. According to Miltner et al. (1999), increased gamma activity is also connected to associated learning, and found that gamma band coherence expands between brain regions that takes in the two types of stimuli needed in an associative learning procedure. Hebb (1949) suggested that brain communication occurs when cells are activated and fire synchronously, strengthening synaptic linkages. Mitner et al. (1999) proposed that such a heightened coherence between the brain's regions may meet the requirements necessary for the formation of hebbian cell assemblies, linking and strengthening areas of the brain that are required to communicate together in order for associative learning to occur. Mitner et al. (1999) further suggest that coherence may be an indicator of associated and other types of learning.

Many of the previous studies using AVS targeted slower brain frequencies and numerous sessions (Carter & Russell, 1993, 1994; Joyce & Siever, 2000; Olmstead, 2000; 2001; Patrick, 1994). This research study targeted faster brain frequencies in the high beta and gamma range (20-40Hz) when applying auditory and visual stimulation based on studies finding that faster frequencies were associated with learning (Miltner et al., 1999; Singer & Grey, 1995; Singer, 1990). These studies suggest that brainwave coherence in the gamma range may increase and strengthen synaptic linkages through the synchronistic firing of activated neural cells.

This researcher also attempted to use AVS to affect the process of increased right/left integration in children with learning disorders who demonstrated specific weaknesses in encoding, sequencing, numerical ability, visual motor speed and accuracy, and short-term memory. Null Hypotheses 1 through 6 were stated that AVS would not produce significant changes in cognitive weakness as measured on the four subtests of the WISC-III (Symbol Search, Coding, Arithmetic, and Digit Span) and 2 Indices (Freedom from Distractability and Processing Speed). Research questions 7 and 8 were analyzed to determine if there were any relationships among the older and younger groups and the six subtest scores.

Dendritic Growth and Neuronal Activation

In a series of investigations, Diamond (1988) theorized that the intensity of environmental stimulation would increase or decrease dendritic growth on a neuronal level, and result in amplifying the brains' ability to carry and process information. Diamond (1988) discovered that when rats were exposed to enriched environmental stimuli, both brain weight and density increased, suggesting an increase of nerve fibers known as axons and dendrites. Diamond (1988) also found evidence of molecular, synaptic, and behavior changes which resulted in improved performance on tasks, such as maze learning and memory in animal studies.

Postmortem human studies later revealed that individuals exposed to a challenging environment demonstrate greater dendritic length and structural changes in the cortex (Kolb & Whishaw, 1990; Snowdon, 1997; Snowdon et al., 1996). Because extension in dendritic growth can be associated with enhanced cognitive abilities, these studies concluded that if an individual was afforded a stimulating and challenging environment, physiological changes could occur within the brain, resulting in enhanced cognitive functioning.

Earlier, Spinelli and Pribram (1967) found that electrode stimulation of the frontal cortex in animals produced significant improvement in the recovery of neurons in the visual cortex as measured by average evoked potentials. Average evoked potential are an electro-encephalographic measurement of a neural impulse. These results revealed that the frontal cortex can affect visual input processing, and suggested a mechanism whereby this brain region can change the amount of attention paid to external stimuli. This finding is important in regard to the deficits in information processing and memory in those with learning disabilities. If electrode stimulation of the prefrontal cortex in animals results in significant neuronal recovery, the possibility remains that visual stimulation induced through the optic nerve into the visual cortex can produce increases in neuronal activity within this same region, and possibly reverse or alter deficits.

Effects of Light Stimulation in Animal and Human Studies

Previous animal and human studies demonstrated that photic or light stimulation (PS) increased cerebral blood flow and glucose uptake much more than oxygen consumption (Aaslid, 1987; Bryan, 1990; Fox, Burton, & Reichle, 1987; Hossman; & Lin, 1987; Phelps & Kuhl, 1981; Reivich & Gur, 1985; Roland; Eriksson, Stone-Elander, & Widen, 1988). Another study suggested that photic stimulation activates anaerobic glycolysis, an anaerobic enzymatic conversion of glucose to the simpler compounds lactate or pyruvate, resulting in energy stored in the form of adenosine triphosphate (ATP), which are used as electron acceptors (Fox, Raichle, Mintum, & Dence, 1988). Studies have found that some LD/ADHD participants have lower levels of glucose and decreased cerebral metabolism in the prefrontal region of the frontal lobe (Hynde et al., 1990; Matochik et al., 1994; Zametkin et al., 1990).

It is generally accepted that neuronal activity in the brain is energized by the hydrolysis of adenosinetriphosophate (ATP) which is predominantly generated by the complete oxidation of glucose to carbon dioxide (Siesjo, 1978) in human participants. Fox et al. (1988) found that PS was associated with a much more significant increase in brain glucose uptake and blood flow than oxygen consumption. This observation suggested the possibility that specific types of functional activity could selectively stimulate anaerobic glycolysis, which would in turn increase lactate production in the absence of a parallel increase in the oxidative metabolism. With the use of magnetic resonance spectroscopy (MRS), Prichard et al. (1991) found that PS induced a rise in lactate in the human visual cortex which is consistent with the theory that sensory stimulation might selectively increase anaerobic glycolysis in the sensory cortex. Sappey-Marinier et al (1992) found statistically significant increase in lactate during photic stimulation and found that PS caused an increase in brain activity resulting in selectively stimulating glycolysis. A later study (Kato, Murashita, Shiori, Hamakawawa, & Inubushi, 1996) confirmed the findings of Sappey-Marinier et al. These findings are consistent with the theory that stimulation of brain functional activity is associated with increased glucose uptake.

Summary

Early studies found that electrical stimulation administered to the frontal cortex in animals demonstrate significant enhanced recovery of neurons in the visual cortex, suggesting increases in visual input processing and improved attention paid to external stimuli (Spinelli & Pilbram, 1967). Diamond (1988) discovered that challenging environmental stimulus result in increases in dendritic growth, brain weight and density, as well as changes in molecular, synaptic, and behavior in animal studies resulting in increased memory and maze learning. Later, many studies found greater dendritic length and structural changes in the cortex of postmortem humans who had lead more challenging lives (Kolb & Whilshaw, 1995; Snowdon, 1997; Snowdon et al., 1996).

Neurobiological studies have discovered a reduction in brain activation, neurological delays, cerebral asymmetry, and decreased cerebral metabolism within the prefrontal and premotor region within the frontal lobe of LD/ADHD participants (Hynde et al., 1990; Matochik et al., 1994; Zametkin et al., 1990).

An early study demonstrated that photic driving was associated with increased brain glucose uptake and blood flow (Fox, Raichle, Mintum, & Dence, 1988). Other studies found photic stimulation caused an increase in lactate in the human visual cortex, increasing glucose levels in the brain

(Prichard et al., 1991; Sappey-Marinier et al., 1992). Sappey-Marinier et al. (1992) concluded that these changes may result in increase brain metabolism and brain lactate concentrations. Singh et al (1991) demonstrated that auditory and visual simulation resulted in stimulation of the cerebral cortex.

Neuroimaging studies have implicated deficits in frontal lobe functioning (Barkley, 1997; Denkla, 1994, 1996a, 1996b; Mesulam, 1990; Stuss, 1992), differences in corpus callosum measures (Giedd, et al., 1994), decreased brain volume (Castellanos et al., 1996; Filpatrick et al., 1997; Hynd et al., 1991), impaired cognitive and behavioral functioning and brain abnormalities in those with LD/ADHD (Barkley, 1992, 1997). Although none of the current findings result in locating a primary cause of the pathophysiology of ADHD, many studies do agree that there are fundamental neuroanatomical abnormalities within the developing brain of ADHD/LD individuals that affect overall functioning.

Studies using AVE with LD/ADHD children have found increases in cognitive processes and enhanced academic performance as demonstrated on standardized testing (Carter & Russell, 1981; 1993; 1994; 1995; Micheletti, 1998; Patrick, 1994). Other studies found that AVS decreased the symptoms and improved problem behaviors in ADHD children (Joyce & Siever, 2001, Olmstead, 2000, 2001) and children diagnosed with autism (Woodbury, 1996). Though all of these studies demonstrate varying improvements in standardized tests, tests of impulsivity, and behavior, few of these studies addressed the changes in specific cognitive functions known to be common to LD.

The current study used newer technology and higher brain frequencies than previous studies to determine if AVS improved specific cognitive weaknesses known to be common in children diagnosed with LD. Null Hypotheses 1 through 6 stated that AVS would not produce significant changes in cognitive abilities as measured by four subtests of the WISC-III, and the FFD and PS indexes. Null Hypotheses 7 and 8 analyzed correlations between the two groups (older and younger), and between the subtest scores (Arithmetic, Digit Span, Coding, Symbol Search, Freedom From Distractability and Processing Speed). The study utilized the WISC-III SCAD profile to measure changes in children diagnosed with learning disabilities after 12 biweekly AVS sessions. Chapter 3 will discuss the research methodology, and include a description of the equipment, specific procedures, and demographics of the population from which the sample was drawn. Chapter 4 will discuss the research results and explain the procedure for data collection and analysis. Finally, chapter 5 will discuss the null hypothesis and address the effect of the study in regards to findings and imitations of the study.

CHAPTER 3

Research Method

Introduction and Null Hypotheses

The Null Hypotheses stated for this study were that auditory and visual stimulation would not produce changes in specific cognitive weaknesses in children ages 6 through 16 diagnosed with Learning Disabilities (LD). These children demonstrated low average to below average scores on the SCAD profile of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III; Wechsler, 1991a) SCAD which is comprised of four subtests which include Symbol Search, Coding, Arithmetic, and Digit Span.

Data Gathering

An Informed Consent Form (see Appendix C) was signed and returned by all parents. All participants were screened for seizures, migraine, and prior head trauma. All participants had an initial diagnosis of LD. All participants were administered the Wechsler Intelligence Scale for Children Third Edition SCAD profile. Regardless of their specific learning disability diagnoses (LD/ADHD), those participants who demonstrated low or below average scores on all of the four subtests (Symbol Search, Coding, Arithmetic, and Digit Span) were admitted into this study. Scores on the Freedom From Distractability and Processing Speed indexes were also obtained.

No participants were undergoing individual behavioral modification therapy by a private therapist, or were involved in any school based behavioral intervention programs while in this study.

All participants' names were held confidential, and the results of the study were made available upon request to the parents of those who participated. Permission for possible publication of results was obtained and confidentiality of individual participants was guarded.

Participants

The participants of this study were children diagnosed with learning disabilities located in the Broward County area of Florida. The children ranged in age from 6 to 16 years of age, and were from varying socioeconomic backgrounds. There was an over-representation of boys in this study (24 boys and 6 girls), which may be accounted for as there is a general over-representation of LD/ADHD boys to girls found in much of the literature (Anderson, Williams, McGee, & Silva, 1987; Baumgartel, Wolraich, & Dietrich, 1995, Wang, Chong, Chou, & Yang, 1993). Many of the children were recommended by therapists, psychologists, and other private clinical practitioners of a large psychology practice. The children were volunteered by their parents and agreed to be in the study. Study explanation and testing procedures were explained to both parents and children prior to signing a Study Consent Form and the administration of the WISC-III SCAD profile. The child was read the Child Assent Form as an explanation to the study (see Appendix C).

To qualify for the study all children had been diagnosed with a learning disability by a licensed psychologist or a school psychologist, and demonstrated low or below average scores on the SCAD profile of the WISC-III SCAD profile. The entire group consisted of 30 student volunteers. Because of the wide variety of learning disorders, the principle qualifying factor chosen was the diagnosis of LD with low or below average scores of the WISC-III SCAD profile.

Participants undergoing AVS were screened to eliminate those with migraine or history of headache or head trauma, including seizure disorder or epilepsy, and concussion. Though the presence of a learning disability was the primary criteria for induction in the study, many children with some form of LD also were also diagnosed with ADHD. The diagnoses of Attention-Deficit Hyperactivity Disorder (ADHD) was based upon the criteria of the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition, Revised (DSM- IV-TR; American Psychiatric Association, 2000).

Instrumentation

The measures included the WISC-III (Wechsler, 1991a) SCAD profile consisting of the Symbol Search, Coding, Arithmetic, and Digit Span subtests. This profile was selected because children diagnosed with learning difficulties are found to score particularly lower on these subtests than same age peers (Bannatyne, 1974; Wielkiewicz, 1990). Similarly, the SCAD profile yields two additional index scores: Freedom From Distractability on which ADHD children tended to perform relatively low, and Processing Speed, which measures overall processing speed. A specific concern was the practice test effect that could occur within a 6-week period. The dependent measures were carefully selected for the high reliability and validity characteristics.

The WISC-III factor indices are expressed as standard scores with a mean of 100 and a standard deviation of 15, with reliability coefficients which range from .85 to .94 and standard errors of measurement from 5.83 to 3.78 (Wechsler, 1991).

The WISC-III SCAD profile was chosen as a measure as it is agreed that individuals with learning disabilities perform lowest on tasks requiring sequential processing, which is expressed in difficulties with planning, numerical ability, reading, and distractability (Bannatyne, 1974; Reinecke, Beebe, Dean, & Stein, 1999; Searls, 1997). Research suggests that low scores on specific subtests of the WISC-III indicate weaknesses in executive abilities in which the individual experiences difficulty attending to stimuli while performing other mental tasks simultaneously (Wielkewicz, 1990). In children, the outcome of these cognitive deficits results in poor academic performance. The SCAD profile was found to be demonstrated by the largest percentage of participants in a study by Ward, Ward, Hatt, Young, and Mollner (1995) and a recent study using the SCAD profile support its diagnostic utility for children with ADHD (Snow & Sapp, 2001). Additionally, the SCAD profile was also chosen as it yields two additional factor scores, Freedom From Distractability (FFD) and Processing Speed (PS) indexes. Children with ADHD are found to score particularly lower on the FFD index (Anastopolous, Spiso, & Maher, 1994).

The WISC-III SCAD profile was administered to each participant prior to undergoing 12 biweekly 35 minute AVS sessions. Upon completion of the 12 AVS sessions, the SCAD subtests were re-administered.

Apparatus

The AVS device called the Pro Tutor was provided on loan from Photosonix Inc. This is a small, plastic, battery-operated device that is one of many available for relaxation and “recreational” use. Devices such as this have gained attention in the popular press such as *The Wall Street Journal*, *The New York Times*, and magazines such as *National Geographic*, *Omni*, and *Time*. The most often described benefit of such technology is relaxation and increases in mental and physical energy.

The AVS system consisted of the Pro Tutor device, headphones, white full spectrum eyeglasses, and a cassette or CD player with a selection of Walt Disney story soundtracks. The Pro Tutor device was set at 50% to full intensity in both light and sound controls depending on participant comfort level. A microchip was programed by this investigator to activate and control the frequency of the flickering lights and tones, which begin at 14 Hz and increased every 5 minutes to achieve 40 Hz The alternating program began at 40 Hz and decreased every 5 minutes until it reached 14 Hz. The AVS sessions were alternated from a 35-minute Excitatory Program (14 Hz increasing to 40 Hz) to a 35-minute Inhibitory Program (40 Hz To 14 Hz).

Procedure

This study design was quasi-experimental with a convenience, nonrandom sample, and repeated measures, with no comparison group. An Information for Participants flyer was used to help recruit participants for the study (see Appendix C). After the initial screening and the signing of the Study Consent and Child Assent Forms (Appendix B and C), each participant was administered the SCAD subtests of the WISC-III. If the study criterion was met as measured by low or below average scores on the WISC-III subtests, systematic AVS treatment was administered 2 times a week for a total of 6 weeks. The participants were brought by their parent or guardian mid-afternoon on weekdays. Participants underwent testing in a specific room designated for pre and post testing. A separate room was designated for AVS treatment. Participants put on headsets and light goggles and underwent AVS while reclining in a comfortable chair. Children were given the choice to listen to a story on cassette tape or compact disc while undergoing AVS. When the story was chosen and the light glasses and headphones were in place, the AVS session begun. All children were monitored by the researcher while undergoing AVS. All participants underwent 2 weekly AVS sessions. Each participant received one Excitatory and one Inhibitory session a week for 6 weeks, for a total of 12 alternating Excitatory and Inhibitory AVS sessions. Sessions were scheduled by appointment at the office of a private psychology office in South Florida. Upon completion of the 12 AVS sessions, posttesting was administered using the WISC-III SCAD profile. Scoring was based strictly on the scoring rules for each subtest. Standard scores were determined using appropriate norms. The data for each participant were transferred to a WISC-III score summary sheet and then entered into a spreadsheet on a computer. WISC-III scores were transformed to an adjusted score based on a mean of 100 and a Standard Deviation of 10. This allowed direct comparison of scores between pre and posttest scores. Analysis was conducted using the Statistical Package for the Social Sciences (SPSS).

Data Collection and Analysis

Two types of analysis were used to interpret the test data. An analysis of variance **(**ANOVA**)** and a paired samples *t* test were used. Research questions 1 through 6 were analyzed with paired samples *t* tests to determine if there were significant changes from the mean pretest to the mean posttest of the six

WISC-III subtest scales, including Freedom From Distractability and Processing Speed indexes. Research questions 7 and 8 were analyzed with the Pearson product moment correlation to determine if there were any relationships among the six variables. Significance levels were set at .05 for all tests. Data analysis was analyzed using the Statistical Package for the Social Sciences (SPSS).

The independent variable in the study was the AVS treatment. The WISC-III SCAD profile subtests, which emphasize the functions of speed of information processing, visual short-term memory, visual-motor coordination, and number ability and sequencing, acted as dependent variables, and are described as follows:

1. Visual-motor coordination, planning, encoding information in preparation for

further processing as measured by the WISC-III Symbol Search subtest.

2. Visual short-term memory and sequencing ability as measured by the Coding subtest.

3. Auditory memory, sequencing ability, concentration and attention as measured

by the WISC-III subtest Arithmetic.

4. Immediate rote recall, concentration and attention, auditory sequencing, and rote learning as measured by the WISC-III Digit Span subtest.

5. Ability to Attend as measured by the WISC-III Index Freedom From Distractability.

6. Speed of information processing as measured by the Processing Speed Index. The results of each WISC-III subtest were compared pre and posttest. Since there has been little research with AVS and measuring specific cognitive abilities, assessment using the WISC-III, which is known to have good reliability and validity with regard to assessing specific weaknesses common in learning disabilities, was chosen.

The seventh null hypothesis was that there would be no relationship between age and subtest scores, and compared the pretest and posttest mean scores of younger and older participants the WISC-III SCAD profile. The eighth null hypothesis was that there would be no correlation among the dependent measures (Arithmetic, Digit Span, Coding, Symbol Search, and the indexes Freedom From Distractability and Processing Speed) and a correlation of all the dependent measures was analyzed.

CHAPTER 4

Results

Introduction

This study used auditory and visual stimulation technology to investigate if significant changes in cognitive abilities could occur in only 12 applied AVS sessions. The null hypothesis was that no significant changes would occur within the four specific cognitive weaknesses known to children diagnosed with learning disabilities. These cognitive abilities include encoding and sequencing, numerical ability, visual motor speed and accuracy, and short-term memory.

Null Hypothesis 1

The first null hypothesis was that auditory and visual stimulation (AVS) would produce no change in the speed of information processing and visual-motor coordination as measured by mean pre and posttest of the Symbol Search subtest of the WISC-III..

An ANOVA and a paired samples *t* test were used to answer the question as it takes into account the significant differences in both sample means, pretest and posttest. The dependent variable was the Symbol Search subtest, with the independent variable as the AVS treatment.

In this study, all 30 were administered the AVS treatment. The children were compared using correlated *t* tests. The results of the ANOVA (see Table 1) revealed significant changes from a pretest mean of 6.9 to a posttest mean of 10.6, $t = 6.24$, $p < .00$. This shows a statistically significant gain in the participant's speed of information processing and visual motor coordination on the Symbol Search subtest. Therefore, the null hypothesis was rejected.

Table 1

Summary data for subtest scores pre and posttest of the WISC-III SCAD Profile (n = 30).

Variable	Pretest		Posttest			
	M	SD	M	SD	*t*	*p*
Arithmetic	6.2	2.6	8.3	2.7	5.3	0
Digit Span	7	2.5	9.6	3.4	7.4	0
Coding	6	2.8	8.2	2.9	4.2	0
Symbol Search	6.9	2.2	10.6	2.8	6.2	0
FD	13.2	4.3	17.5	5.5	6.8	0
PS	12.9	3.9	18.8	4.7	6.8	0

Null Hypothesis 2

The second null hypothesis was that auditory and visual stimulation (AVS) would produce no change in the ability to encode and process information as measured by the Coding subtest of the WISC-III.

ANOVA and a paired samples *t* test were used to answer the question. The dependent variable was the Coding subtest with the independent variable as the AVS treatment. In this study, all 30 participants were administered the AVS treatment. The results of the ANOVA (see Table 1) revealed significant changes from a pretest mean of 6.0 to a posttest mean of 8.2, $t = 4.2$, $p < .00$. This shows a statistically significant gain in the participant's visual short-term memory and sequencing ability as measured by the Coding subtest. Therefore, the null hypothesis was rejected.

Null Hypothesis 3

The third null hypothesis was that auditory and visual stimulation (AVS) would produce no change on number ability and short-term memory as measured by the subtest Arithmetic of the WISC-III.

An ANOVA and a paired samples *t* test were used to answer the question. The dependent variable was the Arithmetic subtest with the independent variable as the AVS treatment. All 30 children were administered the AVS treatment. The results of the ANOVA (see Table 1) revealed significant improvements from a pretest mean of 6.27 to posttest mean of 8.37, $t = 5.38$, $p < .00$. which demonstrates a significant gain in the participants number ability and short-term memory as measured by the Arithmetic subtest. Therefore the null hypothesis was rejected.

Null Hypothesis 4

The fourth null hypothesis was that AVS would produce no change in short term memory as measured by the Digit Span subtest of the WISC-III.

An ANOVA and a paired samples *t* test were used to answer the question. The dependent variable was the Digit Span subtest with the independent variable as the AVS treatment. All 30 participants were administered the AVS treatment. The results of the ANOVA (see Table 1) revealed significant changes from a pretest mean of 7.07 to posttest mean of 9.60, $t = 7.49$, $p < .00$ demonstrating a significant improvement in the participant's immediate rote recall, concentration and attention, auditory sequencing, and rote learning as measured by the Digit Span subtest. Therefore, the null hypothesis was rejected.

Null Hypothesis 5

The fifth null hypothesis was that AVS would produce no change in the ability to attend and concentrate as measured by the Freedom From Distractability Index of the WISC-III.

An ANOVA and a paired samples *t* test were used to answer the question. The dependent variable was the Freedom From Distractability Index with the independent variable as the AVS treatment. All 30 children participated in the AVS treatment. The results of the ANOVA (see Table 1) revealed significant changes from a pretest mean of 13.2 to a posttest mean of 17.5, $t = 6.8$, $p < .00$ demonstrating a significant increase in the participant's ability to attend and concentrate as measured by the posttest of the Freedom From Distractability (FFD) Index. Therefore, the null hypothesis was rejected.

Table 2

Comparison of pretest and posttest mean scores of Younger and Older Participants of WISC - III SCAD profile.

Group Variable	Pretest M	Pretest SD	Posttest M	Posttest SD	*t*	*p*
Younger Arithmetic	6	2.7	8.5	2.9	4.1	0.01
Older Arithmetic	6.5	2.6	8.1	2.5	3.9	0.02
Younger Digit Span	6.7	2.7	9.1	3.8	6.4	0
Older Digit Span	7.5	2.2	10.2	2.7	4.2	0.01
Younger Coding	6	2.9	7.9	2.4	2.8	0
Older Coding	6	2.8	8.5	3.5	3.1	0.09
Younger Symbol Search	7.1	2.6	10.1	2.6	4.4	0
Older Symbol Search	6.5	1.6	11.3	3	4.5	0.01
Younger FFD	12.7	5.2	17.5	6.3	6.2	0
Older FFD	14	2.5	17.5	4.2	3.3	0.07
Younger PS	13.1	4.2	18	4.2	4.3	0
Older PS	12.5	3.4	20	5.5	5.8	0

Note: Younger n = 18, Older n = 12.

Null Hypothesis 6

The sixth null hypothesis was that AVS would produce no change in processing speed as measured by the Processing Speed Index of the WISC-III.

ANOVA and a paired samples *t* test were used to answer the question. The dependent variable was the Processing Speed Index with the independent variable as the AVS treatment. In this study, all 30 children participated in the AVS treatment. The results of the ANOVA (see Table 1) revealed significant changes from a pretest mean of 12.9 to a posttest mean of 18.8, $t = 6.83$, $p < .00$ demonstrating a significant increase in the participant's overall processing speed ability as measured by the Processing Speed (PSI) Index. Therefore, the null hypothesis was rejected.

Null Hypothesis 7

The seventh null hypothesis was that there would be no relationship between age and subtest scores (Arithmetic, Coding, Digit Span, Symbol Search, Freedom from Distractability, and Processing Speed).

The Pearson correlational coefficient was used to answer the questions as it describes the linear relationship between the two interval variables. The dependent variables were the Symbol Search, Coding, Arithmetic, and Digit Span subtests, and the Freedom From Distractability and Processing Speed indexes. The independent variable was the AVS treatment. All children participated in the AVS treatment. The sample was divided into two groups, young (ages 6 to 10) and older (ages 11 to 16). There were 18 participants in the younger group and 12 in the older group. The young and older groups were compared pre and posttest on all subtests, including the two indexes. On all of the correlated *t* tests, the young and older children showed significant gains pretest to posttest (See Table 2). On the Symbol Search subtest, the younger participants went from a pretest mean of 7.1 to a posttest of 10.1, $t = 4.4.$, $p < .00$. The older participants progressed from a pretest mean of 6.5 to a posttest mean of 11.3, $t = 4.5$, $p < 01$. On the Coding subtest the younger participants went from a pretest mean of 6.0 to a posttest mean of 7.9, $t = 2.8$, $p < .00$. The older participants progressed from a pretest mean of 6.5 to a posttest mean of 8.5, $t = 3.1$, $p < 09$. On the Arithmetic subtest, the younger participants went from a pretest mean of 6.0 to a posttest mean of 8.5, $t = 4.1$, $p < .01$. The older participants progressed from a pretest mean of 6.5 to a posttest mean of 8.1, $t = 3.9$, $p < 02$. On the Digit Span subtest, the younger participants went from a pretest mean of 6.7 to a posttest mean of 9.1, $t = 6.4$, $p < .00$. The older participants progressed from a pretest mean of 7.5 to a posttest mean of 10.2, $t = 4.2$, $p < 01$. On the Freedom from Distractability Index the younger participants went from a pretest mean of 12.7 to a posttest mean of 17.5, $t = 6.2$, $p < .00$. The older participants progressed from a pretest mean of 14.0 to a posttest mean of 17.5, $t = 3.3$, $p < 07$. Finally, on the Processing Speed Index the younger participants went from a pretest mean of 13.1 to a posttest mean of 18.0, $t = 4.3$, $p < .00$. The older participants progressed from a pretest mean of 12.5 to a posttest mean of 20.0, $t = 5.8$, $p < 00$. These findings demonstrate the null hypothesis was rejected.

Null Hypothesis 8

The eighth null hypothesis was that there would be no correlations among the dependent measures (Arithmetic, Digit Span, Coding, Symbol Search, and the indexes Freedom From Distractability and Processing Speed). The variables were correlated with each other using the Pearson product moment correlation. Amongst these were five statistically significant correlates: Arithmetic and Digit Span $r = .39$, $p < .05$), Arithmetic and Freedom From Distractability $r = .83$, $p < .01$), Digit Span and Freedom From Distractability $r = .83$, $p < .01$), Coding and Processing Speed $r = .82$, $p < .01$), and Symbol Search and Processing Speed $r = .07$, $p < .01$). These findings demonstrate the null hypothesis was rejected. See Table 3. Findings

Table 1 represents the cell means and standard deviations for the pretest and posttest scores from the WISC-III SCAD profile. The children were compared pretest to posttest on the following subtests Arithmetic, Digit Span, Symbol, Search, Coding, and the Freedom From Distractability, and Processing Speed indexes of the Wechsler Intelligence Scale for Children-Third Edition, using correlated *t* tests, after undergoing 12 biweekly AVS sessions in 6 weeks. On all of the measures the children made significant improvements. For example, on the Digit Span subtest, the children showed improvement from a pretest mean of 7.0 to a posttest mean of 9.6, t = to 7. 4, $p = .00$. This demonstrates a statistically significant gain in short-term memory as demonstrated by the Digit Span subtest. The other five comparisons including the Symbol Search, Coding, and Arithmetic subtests, all demonstrated significant similar statistically significant changes in pretest to posttest means. See Table 1.

With regard to null hypothesis 7, the sample was divided into two groups, ages 6 through 10 and ages 11 through 16. The younger group included 18 children, with the remaining 12 children in the older group. Both groups were each compared from pretest to posttest on all of the correlated *t* tests. All children in both groups demonstrated significant gains. For example, on the Symbol Search subtest, the younger participants went from a mean of 7.1 to a posttest of 10.1, $t = 4.4$, $p = .00$. The older participants progressed from a mean of 6.5 to a mean of 11.3, $t = 4.5$, p = 01. See Table 2. There were consistent gains on all 6 variables of the SCAD profile including the two indexes. Both measures, the ANOVA and the Pearson correlational coefficient demonstrated that not all variables were related. See Table 2.

To investigate null hypothesis 8, the variables were correlated with each other using the Pearson Product Moment Correlation. Amongst these were five correlations that were statistically significant, Arithmetic and Digit Span $r = .39$, $p < .05$), Arithmetic and Freedom From Distractability $r = .83$, $p < .01$), Digit Span and Freedom From Distractability $r = .83$, $p < .01$), Coding and Processing Speed $r = .82$, $p < .01$), and Symbol Search and Processing Speed $r = .07$, $p < .01$). The high correlations between the scores between Arithmetic and Digit Span in this study reflect what the literature has found with regard to these subtests being highly correlated (Bannatyne, 1974; Kaufman, 1994; Prifitera & Dersh, 1993; Wielkiewicz, 1990). The Freedom from Distractability index is comprised of Arithmetic and Digit Span, which are related constructs in terms of concentration, attention, and short-term memory. These scores are thought to be lowered by poor number abilities, and weakness in making mental shifts (Groth-Marnat, 1997).

The Processing Speed factor is comprised of Symbol Search and Coding, and in general reflects an individual's mental and motor speed ability, as well and the ability to plan, organize, and develop relevant strategies (Groth-Marnat, 1977). Again, the highly correlated scores in this study reflect what research findings have indicated with regard to the high correlations between the subtests that make up the factor indexes (Bannatyne, 1974, Kaufman, 1994; Prifitera & Dersh, 1993; Wielkiewicz, 1990). See Table 3.

Table 3

Correlations Scores Between WISC-III SCAD Profile Subtests Arithmetic (Arith), Digit Span (DS), Coding (CD), Symbol Search (SS), Freedom from Distractability (FD), and Processing Speed (PS) Indexes.

Variable	Arith	DS	CD	SS	FD	PS
Arith	1	.39*	0.03	0.1	.83**	0.02
DS		1	0.11	0.01	.83**	0.08
CD			1	0.17	0.09	.82**
SS				1	0.05	.07**
FD					1	0.04
PS						1

Note: * p< .05

**p< .01

Summary

Study results demonstrated a rejection of all null hypotheses. With regard to Null Hypotheses 1 through 6, all children when compared pretest to posttest on the Arithmetic, Digit Span, Symbol, Search, Coding subtests, Freedom From Distractability, and Processing Speed demonstrated significant improvements. With regard to Null Hypothesis 7, both the younger and older groups of children when compared pretest to posttest on all correlated *t* tests demonstrated significant gains. Finally, Null Hypothesis 8 was rejected due to the highly correlated scores between specific subtests, which reflected other research findings with regard to the high correlations between the subtests that make up the factor indexes

CHAPTER 5

Discussion, Recommendations, Summary

Introduction

This investigation was designed to assess any change in specific cognitive abilities in children with learning disabilities using auditory and visual stimulation (AVS). The Wechsler Intelligence Scale for Children-Third Edition (WISC-III) was chosen as the measurement instrument for its good reliability and validity. The size of the study sample was 30 participants. The goal of the study was to investigate the use of auditory and visual stimulation as a treatment for learning-disabled children. The Null Hypotheses stated that AVS would not produce significant changes in any of the specific cognitive abilities measured in children diagnosed with learning disabilities. Analyses were conducted using a paired samples *t* test and a Pearson product moment correlation. The following Null Hypotheses were proposed:

The first null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t* test, $p < .05$) between the mean pre and posttest scores of the speed of information processing and visual-motor coordination as measured by the Symbol Search subtest of the WISC-III.

The second null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t* test, $p < .05$) between the mean pre and posttest scores of information processing and visual-motor coordination as measured by the Coding subtest of the WISC-III.

The third null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t test*, $p < .05$) between the mean pre and posttest scores of number ability and short-term memory as measured by the Arithmetic subtest of the WISC-III.

The fourth null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t* test, $p < .05$) between the mean pre and posttest scores of short term memory as measured by the Digit Span subtest of the WISC-III.

The fifth null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t* test, $p < .05$) between the mean pre and posttest scores of the ability to attend and concentrate as measured by the Freedom From Distractability (FFD) Index of the WISC-III.

The sixth null hypothesis predicted that auditory and visual stimulation (AVS) would produce no significant difference (*t* test, $p < .05$) between the mean pre and posttest scores of overall processing speed as measured by the Processing Speed (PS) Index of the WISC-III.

The seventh null hypothesis predicted that there would be no relationship between age and WISC-III subtest scores ($p < .05$).

The eighth null hypothesis predicted that there would no significant correlations among the dependent measures of Symbol Search, Coding, Arithmetic, Digit Span, FFD and PS of the WISC-III ($p < .05$).

Discussion

The hypotheses for the study were that AVS would not affect any of the the specific cognitive abilities in learning-disabled children. The results of the ANOVA demonstrated significant gains in pretest to posttest means on all variables. A confidence level of .05 was used as the criterion for rejection of the null hypotheses. An analysis of variance test of significance was used for all measures in the null hypotheses 1 through 6. The children were compared on all variables and on all measures the children made significant improvements ($p = .00$). See Table 1.

Among studies using similar technology, only one used some of the same measures, specifically the Processing Speed (PS) and Freedom From Distractability (FFD) Indices of the WISC-III (Patrick, 1994). Patrick used the FFD Index to help measure attention, along with other measures (TOVA, RPM, CBCL-P) and used the PS Index with the TOVA and CBCL-P attention problems profile scale to measure impulsivity. Patrick's study noted statistically significant changes in both PS ($p < .001$) and FFD ($p < .001$). Patrick's design was much different than that of this study with regard to light stimulation, as exposure to photic driving occurred for only 2 to 4 minutes while undergoing neurofeedback (neurotherapy). Similarly, Patrick used a low number (fifteen, 40 to 50-minute daily sessions) and only 32 participants. Though Patrick was evaluating neuronal regulation in children with ADHD, findings were significant post-treatment on the Wechsler Individual Achievement Test (WIAT) scores as demonstrated statistical significance ($p < .05$).

Of all the studies using solely AVS, Micheletti's study (1998) used auditory and visual stimulation (AVS) with the children undergoing 20-minute sessions, 5 days a week, for a total of 40 sessions. The frequencies of the light stimulation began at 10 Hz, switched to 18 Hz for 2 minutes, then return to 10 Hz, with the child experiencing four complete cycles (5 minutes per cycle) for a total of 20 minutes. Though Micheletti (1998) did not use any of the same measures, he found significant changes in cognitive functioning levels as evaluated by IQ tests on the Wide Range Achievement Test (WRAT-R), Peabody Picture Vocabulary Test (PPVT), and Raven Progressive Matrices (Raven's) at $p < .05$, $p < .01$, and .001 level.

To address null hypothesis 7, the Pearson product moment correlation was used to determine if there was any relationship between age and subtest scores (Arithmetic, Coding, Digit Span, Symbol Search, Freedom From Distractability, and Processing Speed). On all of the correlated *t* tests, the young and old children showed significant gains pretest to posttest (see Table 2). The younger children demonstrated more significant scores in all variables ($p = < .00$) with the exception of Arithmetic ($p < .01$). It appeared that the younger children made higher gains that the older children when compared at the .01 level. The younger participants scored most significantly ($p < 0$) in Digit Span, Coding, Symbol Search, FFD, and PS when compared to the older children in these subtests with the exception of Arithmetic ($p < .01$). The most notable difference between the younger and older groups was found in the Coding subtest, which measures psychomotor speed and sequencing ability. Coding subtest scores can be lowered by anxiety as well as depression, as the the psychomotor slowing found in depressive states can produce a decrease in performance levels (Groth-Marnat, 1997).

These results may be important when considering the age to begin AVE intervention in the treatment of LD. This researcher hypothesizes that younger children may make more significant cognitive gains early on due to brain plasticity (the ability of synapses to change as circumstances require). It has been well documented in many studies that during early development the brain is capable of reorganizing patterns and systems of synaptic connections in ways that an older brain cannot (Stiles, 2000). Another factor that may account for younger children making more significant gains may be due to a lower incidence of behavioral difficulties or self-esteem issues that may have not yet developed with regard to difficulties with learning. Findings from the National Longitudinal Study of Adolescent Health (2000) found that adolescent children in grades 7 through 12 are at significantly higher risk than non-LD peers for emotional distress, suicide attempts, and violence (due to repeating a grade, getting into trouble due to behavioral issues, skipping school, etc.). Other studies indicate that adolescents with LD have a higher incidence of emotional distress (Svetaz, Ireland, & Blum, 2000), and significantly higher rates of depression (Goldstein & Dundon, 1986) and symptoms of anxiety (McConaughty & Ritter, 1985;

McConaughty et al., 1994). These findings suggest that earlier intervention to aid in addressing the core deficits of LD appears to be imperative to the future well being of the child diagnosed with learning disabilities.

The second least significant score in comparison to pre and posttest means was found in the FFD index. Younger children demonstrated significant differences pre- and posttest in FFD ($p < 0$), whereas the older group demonstrated less significant change pre and posttest ($p < .07$). Though the Freedom From Distractability Index is a more complex and controversial construct due to its ability to measure a wide range of abilities than solely distractability (concentration, attention, and short-term memory), it is believed to be lowered by anxiety and poor motivation (Groth-Marnat, 1997). For this reason the posttest means of the older group of children may also reflect less change due to either emotional difficulties or the brain's inability to respond as well as the younger group

($p < 0$).

AVS and Brain Physiology

With regard to the possible physiological changes that may have been induced by AVS treatment, studies have shown that photic stimulation significantly increases lactate levels in the brain resulting in increases in brain activity, causing a stimulation of glycolysis (Kato, Murashita, Shiori, Hamakawawa, & Inubushi, 1996; Sappey-Marinier et al., 1992). These findings may hold a clue to understanding the results of an earlier study by this investigator in which AVS was found to decrease stimulant medication intake and ADHD symptoms (Olmstead, 2000). Of the 25 participants taking stimulant medication prior to beginning AVS treatment, 76% were able to reduce or completely discontinue medication and 24% did not. Though this study did not conduct a formal follow-up to measure sustained results, these findings suggested that an AVS treatment program resulted in significant reduction in ADHD symptoms and may be a viable non-drug approach to treating this disorder.

The above findings demonstrate that auditory and visual stimulation resulted in significant mean changes pretest to posttest in the cognitive functions of all learning-disabled participants; therefore, all null hypotheses were rejected. The results of this study, which only used 12 sessions in 6 weeks, offer promising evidence that auditory and visual stimulation technology may be a viable intervention for learning disabilities. It would also appear that AVS may be a physical phenomenon that normalizes brainwave activity and increase neuronal activation resulting in dendritic growth. These findings will perhaps have a significant impact on strengthening the cognitive weaknesses of those with learning disorders, resulting in a multitude of effects which were not addressed in this study. First, the use of this technology could be used to decrease the degree of severity in compromised cognitive abilities such as short-term memory, sequencing, information processing, and focus and attending. Not only will this affect the academic progress by improved grades and overall performance, but it will likely increase the potential for many of these children to obtain higher levels of education and academic successes. If implemented early in life, this technological intervention may also assist in reducing the risk of behavioral and psychological issues which can accompany some of these diagnoses. In addition, early social and academic successes can enhance an individual's self-esteem and self-concept, which can positively impact the quality of relationships with others. With the likely cognitive improvements and continued social and academic successes possibly awarded through the use of AVS, a child diagnosed with learning disabilities can perhaps avoid some of the psychologically crippling and negative social and career limitations that may result without such rehabilitative intervention. With further studies in the use of such simple technology, a learning-disabled child or adult may now have an opportunity to alter his or her life, resulting in increased academic, social and personal successes affecting one's overall quality of life.

Though this study investigated specific cognitive abilities using the WISC-III SCAD profile as opposed to utilizing other measures, such as verbal and processing IQ (Carter & Russell, 1994), achievement tests (Carter & Russell, 1994; Micheletti, 1997; Patrick, 1994), behavior rating scales (Carter & Russell, 1994; Joyce & Siever, 2001; Micheletti, 1997), and computerized tests for impulsivity (Joyce & Siever, 2000; Patrick, 1994), this study confirms that AVS produces significant changes in some cognitive abilities known to be weak in LD participants. Of previous studies investigating AVS efficacy with LD, only one study (Patrick, 1994) used same measures demonstrating significant gains on the WISC-III Processing Speed Index and Freedom From Distractability scales after 15 EEG driven AVS sessions. Micheletti (1997) found significant gains after 40 AVS sessions in cognitive functioning as measured by the WRAT-R, PPVT, and the Ravens Progressive Matrices.

The dependent variable used in this study is well known in research literature for its reliability and validity. The WISC-III SCAD profile has replaced the ACID profile as a reasonable measure of LD (Bannatyne, 1974; Reinke, Beebe, Dean, & Stein, 1999; Searls, 1997; Snow & Sapp, 2001; Ward, Ward, Hatt, Young, & Mollner, 1995). In this study only 12 AVS sessions were applied as opposed to an average of 31 sessions (Joyce & Siever, 2000) or 40 to 80 AVS sessions as used in older studies (Carter & Russell, 1993; Micheletti, 1998). Though this study utilized newer technology and faster frequencies, the lower number of AVS sessions needed to improve cognitive abilities may further demonstrate its efficacy. The AVS sessions were administered two times weekly for a duration of 6 weeks, which may assist in better outcomes, as daily sessions may result in overstimulation of the brain. The choice of music or story soundtrack with regard to the use of AVE did not appear to be a detriment. Additionally, this researcher used higher frequencies that that of other studies (14 - 42 Hz and 42 - 14 Hz). Older studies used frequencies in ranges of 7 to 9 and 12 to 15Hz respectively (Joyce & Siever, 2000), and frequencies between 10 and 18Hz (Carter & Russell, 1993; Micheletti, 1998). Additionally, Patrick's (1994) study used 12 to 14 Hz to decrease the production of high beta activity (48Hz) with photic driven EEG training. This researcher suggests that the most significant gains in specific cognitive improvements are produced by the using faster frequencies in aiding a participant to produce more neuronal stimulation. Although this study did not use any form of brain imaging as a measure, it would appear that changes occurred through the use of frequencies not used in earlier studies. Additionally, this study used white-full spectrum LEDs with regard to the eye glasses, which provided the light stimulus. It is the belief of this researcher that partial range frequency light stimulus such as red or other monochrome colors are not as effective as full spectrum stimulus. Additionally, the light glasses in this study were inset with four LEDs per each eye. Other light stimulus glasses may have only two or three LEDs per eye. Previous studies utilized red or other types of full spectrum glasses made by various manufacturers. The intensity and quality of these light glasses may also be a variable with regard to study results.

Finally, to address Null Hypothesis 8, the variables were then correlated with each other using the Pearson product moment correlation, and findings demonstrated that five correlations were statistically significant.. They were the correlation between Arithmetic and Digit Span $r = .39$, $p < .05$), Arithmetic and Freedom From Distractability $r = .83$, $p < .01$), Digit Span and Freedom From Distractability $r = .83$, $p < .01$), Coding and Processing Speed $r = .82$, $p < .01$), and Symbol Search and Processing Speed $r = .07$, $p < .01$). Again, these findings related positively to the research findings reflecting the high validity and reliability of the SCAD profile scores. See Table 3.

Recommendations

This study investigated only six areas of weakness: visual-motor coordination, visual short-term memory, sequencing, number ability, ability to attend, and speed of information processing. Further investigation of how AVS may affect learning disabilities might include the testing on other specific areas such as reading, comprehension, abstract thinking, social maturity and judgement, writing skills (including penmanship and written expression), listening, speaking, reasoning, and spelling.

A specific weakness in this study was the population size. Though there were only 30 participants, all children did demonstrate significant improvements. Additionally, this study did not use a control group, which is partially due to time restraints and the ethical consideration of withholding medication for those who did not want to discontinue psychostimulant use. There was also a lack of equal age representation (younger group = 18, older group = 12) and gender representation (females = 12, males = 18) in the sample population. Some of the representation may be accounted for by the suggestion that more males are diagnosed with a learning or attentional disorder than are females.

Another limitation of the study was the time between pretest and posttest. Although this researcher has found no data with regard to pretest posttest time restraints with the tests chosen, future studies should have a 6-month to 1-year follow-up measurement period. A longitudinal study design that would allow for both cognitive and behavioral measures to be evaluated is also recommended, and the use of self-reported, parent, and teacher ratings may also be used. Future studies may include a pre- determined -year follow-up to discover if academic recidivism occurs in any specific cognitive ability, and to what extent. Other studies could use brain imaging technology to measure areas of brain activation and particular changes in brain neurophysiology.

Physical exercise and maintenance of healthy living are required for optimal health and longevity. Thus, the importance of any form of brain stimulation for ongoing cognitive maintenance and enhancement should not be underestimated. Evidence now exists that brain stimulation induces an increase in dendritic growth (Boyde; 1998; Diamond, 1988; Kolb & Whilshaw, 1990; Spinelli & Pribram, 1967), significant ameliorated recovery of neurons in the visual cortex (Spinelli & Pribram, 1967), and increased levels of glucose (Kato, Murashita, Shiori, Hamakawawa, & Inubushi, 1996; Sappey-Marinier et al., 1992). If these physiological brain studies demonstrate that auditory and visual stimulation can be associated with enhanced cognitive abilities and functioning, other brain disorders and dysfunction may also be be aided, such as stroke, brain injury, syndromes such as autism, and those diagnosed with mental handicaps.

Summary

This study suggests that the use of AVS challenges and stimulates the brain to change in many ways that may not yet be understood. This researcher wrote the software protocol based on 12 years of previous experimentation with such technology. Though other AVS devices are available for use, the specific sequence of the tones and frequencies with regard to the light and sound stimulus has not been replicated in any other devices. However, the simplicity of the program use and the low cost of the equipment may allow for a relatively safe, quick, treatment intervention for learning disabilities to be available to children who not only need it, but to those who would otherwise not receive such intervention due to socioeconomic level and availability of mental and/or health coverage. Larger studies could lead to an intervention that is easily assessable by trained and licensed professionals, and more importantly, that is a safe, immediate, effective, non drug rehabilitative intervention for learning disabilities and other neurophysiological disorders. This technology has the potential to greatly enhance the quality of life for the learning-disabled individual who would be at risk for social, psychological, and a multitude of personal disappointments and life-long failures without such a treatment intervention.

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APPENDIX A

Use of Auditory and Visual Stimulation (AVS) as Intervention

for Learning Disorders and Attention Deficit Hyperactivity Disorder

Consent Form

Your child is invited to participate in a research study using Auditory and visual stimulation (AVS) as an experimental treatment intervention for a Learning Disorder (LD) or Attention-Deficit /Hyperactivity Disorder (ADHD). Your child was selected as a possible participant because he or she meets the criteria of the American Psychological Association DSM-IV for Attention-Deficit/Hyperactivity Disorder or a type of Learning Disability. For your child to qualify for this study, he or she must additionally score low or below average on the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) SCAD profile, including subtests Symbol Search, Coding, Arithmetic, and Digit Span. You also have stated that your child has no history of, or suffers currently from any of the following:

Please Initial the following:

_____Migraine or history of headache

_____Mental Illness (including depression or anxiety)

_____Seizure disorder or epilepsy

_____Concussion or loss of consciousness

We ask that you read this form and ask any questions you may have before agreeing to participate in the study.

This study is being conducted by Ruth Olmstead, M.A., a Doctoral Candidate at Walden University. She is certified in electroencephalogram (EEG) neurofeedback and has used Auditory and visual stimulation (AVS) therapy extensively in medical and educational settings for twelve years. AVS is an experimental method of brainwave entrainment and stimulation that has been used in a variety of medical and educational settings for many years as an intervention for a variety of disorders.

The purpose of this study is to explore if Auditory and visual stimulation intervention can be effective in the enhancement of academic performance in individuals with LD/ADHD.

Procedures:

If you agree and consent that your child participate in this study, we would ask you and your child to complete the following tasks:

***** Complete four Subtests of the Wechsler Intelligence scale for Children-Third Edition (WISC-III). These Subtests include: Symbol Search, Coding, Arithmetic, and Digit Span. Completion of all subtests will take approximately 20 minutes.

***** If your child qualifies for the study upon completion and scoring of the WISC-III, your child will undergo 12 AVS intervention sessions at no charge.

***** Within 6 months of the prior WISC-III testing, your child will retake the same 4 Subtests to assess changes in sequencing and cognitive abilities.

***** Your child will receive 12 AVS sessions within 6 weeks. Sessions will be administered twice weekly.

Risks and Benefits of Being in the Study:

Although it is unlikely, AVS can have minimal side effects and is not intended to cause undue distress. Some individuals, however, with pre-existing conditions may experience the following temporary side-effects at any time during the course of intervention:

(Please initial all of the following)

______a brief feeling of anxiety or sudden panic

_____ unpleasant and /or disturbing memories

______headache and/or migraine

If any of these conditions occur with your child, the researcher will terminate the study and the parent or care giver will be immediately notified.

The benefits to AVS participation are:

***** Potential decrease in hyperactivity and behavioral problems.

***** Potential improvement in academic abilities such as reading and mathematics.

***** Potential increased attention-span and concentration.

***** Potential enhanced self-esteem.

In the event that this research activity results in long term negative side-effects such as headache or migraine, follow up care must be provided by the parent and/or the child's physician. Payment for any such treatment must be provided by you or your third party payer, if any, (such as health insurance, Medicare, etc.). I agree to totally hold harmless Associates in Behavioral Counseling, Denise Newman Sydnor, Psy. D., and Ruth Olmstead, M.A. for any and all professional liability, for any condition or reaction to AVS or participation in this voluntary study.

Compensation:

You will receive 12 AVS sessions treatments at no charge. You will also be given the results of the final testing on the four subtests of the WISC-III. **12 AVS sessions have a value of approximately $1,800.00.**

WISC-III scoring information are expected to be available within approximately 1 month after all results have been assessed and under the following conditions:

* All study criteria have been met

Confidentiality:

The records of this study will be kept private. In any sort of report that might be published, I will not include any information that will make it possible to identify a participant. Research records will be kept in a locked file at the office of Associates in Behavioral Counseling; only the researcher and her Clinical Supervisor will have access to the records.

Voluntary Nature of the Study:

Your decision whether or not to participate will not affect your current or future relations with Walden University or with other cooperating institutions. If you decide to participate, you are free to withdraw at any time without affecting those relationships. No test results will be available due to early withdrawal.

Contacts and Questions:

The researcher conducting this study is Ruth Olmstead, M.A. under the clinical supervision of Denise Newman Sydnor, Psy.D. / FL # PY0005235. You may ask any questions you have now. If you have questions later, you may contact Ruth Olmstead, M.A. at ASSOCIATES IN BEHAVIORAL COUNSELING, 7800 W. Oakland Park Blvd. Building B / Suite 102, Sunrise, FL 33351 (954) 742-8400.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and received answers. I consent to participate in the study. I agree with each and every stated point in this statement of consent.

Print Name of

Patient:____Date:__________________

Signature of Patient:____ Date:___________________

Signature of Parent or

Guardian when applicable:______________________________________ Date:__________________

Print name of Parent or

Guardian:____ Date: _________________

Signature of Investigator

Ruth Olmstead, M.A.:____Date:__________________

APPENDIX B

Use of Auditory and Visual Stimulation (AVS) to Improve Cognitive Abilities in Learning-Disabled Children

Walden University Dissertation Study

Child Assent Form

You are invited to take part in a special project to help me to discover if lights and sounds can help you learn easier and get better grades in school. I would need your help for 2 days a week for about a half hour each time. You would come and see me for a total of 6 weeks.

If you want to know if you can do better in school, we first have to see know how you are doing right now, so I will also have to give you 4 short little tests. Two of these tests only take 2 minutes to take. After you take the tests, I will know if the lights that you wear might be able to help you learn easier.

Sometimes when we have a hard time learning it is because our brain is not working as well as it could. I am going to try to see if I can help your brain be stronger and work a lot faster with a kind of “brain gym” that I made. My “brain gym” is not like the kind you have at school and it does not have Swings or Jungle Jims! It is made specially for your brain, and you have to put on headphones and glasses to try it. The glasses you wear are special glasses which light up with little white lights, but make lots of colors when you close your eyes. With the headphones you can listen to stories while you wear the glasses. If you decide that you want to try my kind of brain gym, you would sit in a big chair and pick out a story that you might want to listen to. I have lots of Disney stories to choose from. You would also have to wear the headphones and put the glasses on for the whole time the light glasses are blinking. You will probably see lots of colors and designs while you have them on. The lights will blink for 35 minutes, and you will come to use them 2 times a week.

After you have tried the light and sound therapy 12 times, I will give you the same tests that you had before we started, and we will measure any changes that happened.

If you want to work with me, please write your name below:

______________________________ ________________

Child's Name Date

______________________________ ________________

Parent or Legal Guardian Date

______________________________ ________________

Researcher / Witness Date

APPENDIX C

Non-Drug 6 Week Study for Children Diagnosed with

Learning Disorders and ADHD

Information for Participants

If your child has been diagnosed with a learning disability (LD) or attention-deficit/hyperactivity disorder (ADHD), he or she may qualify to be included in a Dissertation study using Auditory and visual stimulation (AVS). This study will attempt to use light and sound stimulation to enhance short-term memory, information processing speed, focus, and concentration. AVS is applied through the use of headphones and specially designed eyeglasses inset with white full-spectrum lights. While reclining in a chair with the headphones your child will listen to a Disney story of their choice while wearing the light glasses. The light glasses will be set at a comfortable level and your child will be expected to keep his or her eyes closed during the session. Session duration will be 35 minutes in length and occur 2 times a week for 6 weeks.

In order to qualify, your child must be diagnosed with a learning disability and will be administered 4 subtests of a standardized IQ test. Your child must score low or below average on all 4 tests to qualify. Upon qualification, Your child will then agree to undergo 12 AVS sessions, 2 times a week, for 6 weeks. After completion of all AVS session, the standardized tests will be re-administered and the test results will be discussed.

In recent studies, AVS has been found to regulate brainwave function, decrease the reliance upon medication, improve concentration abilities and academic performance, and decrease problem behaviors. Clinical studies are available upon request.

For further information contact:

Ruth Olmstead, M.A., Doctoral Candidate

ASSOCIATES IN BEHAVIORAL COUNSELING

7800 W. Oakland Pk. Blvd. Building B / Suite 102

Sunrise, FL 33351

Phone (954) 742-8400

APPENDIX D

Letter for Permission to Conduct Study

Associates in Behavioral Counseling

7800 W. Oakland Park Blvd. Suite 102

Sunrise, Florida 33351

January 7, 2003

Dear Dr. Simpson and Associates in Behavioral Counseling;

Thank you so very much for inviting me to be a part of your wonderful family practice. Along with your expertise in Cognitive Behavioral Therapy, your combined expertise and knowledge in the practice of biofeedback and EEG neurofeedback is greatly valued by me. I look forward to a long, innovative, and successful working relationship with all of you.

As you know, I have recently passed my Oral Presentation and will begin my dissertation study with Walden University fairly soon. I would very much like to conduct my study your office but I need written permission to do so. The study will be for a duration of six weeks, and involve approximately 30 children ages 6 through 15 years of age. The children will undergo auditory and visual entrainment (AVS) sessions two times a week (for approximately 40 minutes each), for a duration of six weeks. I will be the primary researcher and will be responsible for the study sessions. I would appreciate any referrals of children with learning disabilities that you feel may be appropriate for inclusion in the study. The criteria for the study must include a diagnosis of a learning disability and low or below average scores on the WISC-III SCAD profile. Each parent and child are also required to sign a consent and assent form after undergoing a brief introduction and explanation of the study procedure.

Thank you for consideration in this matter.

Sincerely,

Ruth Olmstead

APPENDIX E

Walden University

Request to the Institutional Review Board for Approval

Walden University

Committee on the Ethical Standards in Research

155 Fifth Avenue South

Minneapolis, MN 55401

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1. Project Title: *Use of Auditory and Visual Stimulation to Improve Cognitive Abilities in Learning-disabled Children*

2. Exemption Category Claimed: *Category # 2 - Surveys/Interviews; Standardized Educational Tests*

3. Principal Investigator: Ruth Olmstead, M.A.

Email: rolmstea@waldenu.edu

4. Projected inclusive dates of project: *January 1, 2003 through April 1, 2003*

5. Check one: _______Faculty Research ___X___Student Research (Doctoral)

6. Advisor's Name: Catherine James, Ph.D.

Email: catherin@waldenu.edu

7. Abstract/Lay Summary:

Learning disabilities (LD) fall under many complex definitions with a wide variety of manifestations and theories regarding causation. Cognitive deficits are found in executive functioning which comprises working memory, encoding, visual-motor coordination, response inhibition, planning, and processing (Barkley, 1997; Denkla, 1996; Kaufman,1994; Prifitera & Dersh, 1993). Aside from medication, educational remediation, and classroom interventions, there is no specific intervention which might rehabilitate the cognitive weaknesses associated with learning disorders. Previous studies utilizing auditory and visual stimulation (AVS) have demonstrated enhanced academic performance in learning-disabled children (Budzinski, Jordy, Budzinski, Tang, & Claypoole,1999; Carter & Russell, 1993; Joyce & Siever, 2000; Micheletti, 1998; Patrick, 1997). This study will attempt to investigate the effect of Auditory and visual stimulation (AVS) on the four cognitive abilities known to be weak in children diagnosed with LD utilizing the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) SCAD profile (Symbol Search, Coding, Arithmetic, and Digit Span). The WISC-III SCAD profile will be administered pre and post twelve, biweekly 35 minute AVS sessions. Two additional index scores from the SCAD profile will also be assessed; Freedom from Distractability (FFD) and Processing Speed (PS). The study design is quasi-experimental with repeated measures pre and post treatment. The independent variable in this study was treatment using AVS and an attempt was made to align the dependent measures with the current definition of learning disabilities according to the

Individuals with Disabilities Act (1990), and by the low and below average scores on the WISC-III SCAD profile. Expected findings using a significant level of .05 (two-tailed) will be that AVS does not cause significant changes in specific cognitive abilities as measured by the WISC-III SCAD profile.

8. Participant Population:

a. Number: Male: *Unknown* Female: *Unknown* Total: *30*

b. Age Range: *6 years to 15 years*

c. Location of Participants: *Children from the local community who are referred through Associates in Behavior Counseling in Broward County, South Florida.*

d. Special Characteristics of Participants: *All children must have a formal diagnosis of LD/ADHD and must score low to below average on the WISC-III SCAD profile. No children taking medication will be included in the study*.

e. If research is conducted through community agencies, written documentation of approval/cooperation from such agency (school, etc.) should accompany this application.

f. Describe how participants will be identified or recruited. Attach recruitment information, i.e., advertisements, bulletin boards notices, recruitment letters, etc: *Participants will be recruited through the referrals of Associates in Behavioral Counseling.*

g. If participants are chosen from records, indicate who gave approval for use of the records. If private medical or student records, provide the protocol for securing consent of the participants of the records and approval from the custodian of the records.

h. Who will make the initial contact with participants? Describe how contact is made.

Participants will be recruited through Associates in Behavioral Counseling. Contact with each individual and their parents will be made only through this researcher, accompanied by a full explanation of the study, a description of the device, and followed by the initial interview and intake process. Parent Consent and Child Assent Forms will be read and signed. ***See attached Parent Consent Form and Child Assent Form.***

I. Will participants receive inducements before, or rewards after the study (Note: Include this information in your consent documents.)

Participants will receive WISC-III pre and posttest scores, which will be accompanied by a full interpretation of scores after the study is completed.

j. If participants are school children and class time is used to collect data, describe in detail the activity planned for non-participants. Who will supervise those children? (Note: Include this information in your consent documents). *No class time will be used. Children will be supervised by this researcher when child is undergoing study sessions.*

9. Confidentiality of Data.

a. Describe provisions made to maintain confidentiality of data. Who will have access to data? Will data be made available to anyone other than the principal investigator? (School officials, medical personnel?) If yes, explain below and in the consent form.

No one will have access to the data except Ruth Olmstead, the principal researcher, the children, and the parents of the children after the results are completed.

b. Where will data be stored and for how long? If tape recordings or videotapes are created, explain who will have access and how long the tapes will be retained. Written consent is required for recordings; the consent form should include this information as well. (Walden expects that students will retain their original data for at least five years following approval of the dissertation).

No tape or videotapes will be created. Data will be stored for five years following the approval of the dissertation in a locked file case at the office of Associates in Behavioral Counseling by the principal researcher, and according to the rules and regulations of the State of Florida.

10. Informed Consent Process

Simply giving a consent form to a participant does not constitute informed consent. Using the sample consent form, prepare and attach a consent form, statement, or letter for review

(for exemption categories 1, 2, 3, 5, 6). ***See attached Parent Consent and Child Assent Forms.***

Note: Researchers are cautioned that consent forms should be written in simple declarative sentences. The forms should be jargon free. Foreign language versions should be prepared for any applicable research.

*** Consent form:** Signature of participant and/or parent is required for research involving risk, and for research where a permanent record of results are retained (including videotapes).

*** Consent Statements/letters to participants:** Statements read to study participants or distributed to participants prior to interview or as a cover sheet for a written survey should be modeled after the sample consent form, but do not require signature.

*** No active consent is required for observations of public behavior.** Photos, films, videotaping, etc., require review by the Program Director and written consent of participants.

*** No active consent is required for review of public records, private records already stripped of identifiers, or research involving pathological specimens which are not identifiable by name or number.**

11. Exempt Category #4: Pathological Specimens

All pathological specimens should be stripped of identifiable information prior to use. Registries or tissue banks where participant's samples are identified or identifiable are not exempt from Committee review.

Describe the source of the specimens. How will the be obtained? If not obtained by the principal investigator, then by whom? *No pathological specimens will be used.*

12. Exempt Category #5: Public Service Programs

In addition to the information provided under abstract, above, provide documentation of conformity to the requirements for category #5, including written documentation or cooperation from the public agency involved in the research.

Applications for approval to use human participants in research require the following assurances and signatures:

(Note: original inked signatures are required; no stamps or "per" signatures accepted.)

The signatures below certify that:

* The information provided in this application form is correct.

* The Principal Investigator will seek and obtain prior written approval from the Program Director in the event of any substantive modification in the proposal, including, but not limited to changes in cooperating investigators and agencies, as well as changes in procedures.

* Unexpected or otherwise significant adverse events in the course of this study will be promptly

reported.

* Any significant new findings which develop during the course of this study which may affect the risks and benefits to participation will be reported in writing to the Program Director and to the participants.

* The research may not and will not be initiated until final written approval is granted.

This research, once approved, is participant to continuing review and approval by the Committee Chair and AVPAA. The Principal Investigator will maintain complete and accurate records of this research. If these conditions are not met, approval of this research could be suspended.

Signature of Principal Investigator:_____________________________________Date:________

As Committee Chair, I assume responsibility for ensuring that the student complies with University and federal regulations regarding the use for Human Participants in research. I acknowledge that this research is in keeping with the standards set by the University and assure that the Principal Investigator has met all the requirements for review and approval of this research.

Signature of Committee Chair:____Date:__________

As Associate Vice President for Academic Affairs, or designee, I acknowledge that this research is in keeping with the standards set by the University and assure that the Principal Investigator has met all requirements for review and approval of this research.

Signature of AVPAA:____________________________________ Date:_________

*** Consent form:** Signature of participant and/or parent is required for research involving risk, and for research where a permanent record of results are retained.

*** Consent Statements/letters to participants:** Statements read to study participants or distributed to participants prior to interview or as a cover sheet for a written survey should be modeled after the sample consent form, but do not require signature.

Vitae

Ruth Olmstead

Ft. Lauderdale, FL 33312

Education: Walden University, Minneapolis: MN (1997- Present)

Doctoral Candidate / Honors

Specialization: Professional Psychology (Ph.D.)

Webster University, Albuquerque: NM (1997)

Master of Arts in Counseling / Distinguished Graduate

Northern Illinois University, DeKalb: Il (1982)

Bachelor of Arts

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Clinical and Professional Experience:

2003 *Associates in Behavioral Counseling*

Sunrise, FL: Psychology Resident

Denise Newman Sydnor, Supervisor; Licensed Psychologist / FL #PY 5235

2002 - 2000 *Child & Family Psychologists*

Plantation, FL: Psychology Resident

Mitch Spero, Supervisor; Licensed Psychologist / FL #PY 4098

Individual and Family Therapy; Psychoeducational and Custody Evaluations

1999 - 1997 *North County Center for Educational Development*

Solana Beach, CA.

EEG neurofeedback technician

1997 - 1991 *The Clinic for Health and Wellness*

Albuquerque, NM

EEG neurofeedback technician

1997 *Anna Kaseman Behavioral Health Facility*

Albuquerque, NM: Master's level psychology Intern /Drug and Alcohol Rehabilitation Program. Conducted patient Intakes and co-facilitated group and art therapy.

1996 *Children's Memorial Hospital*

Albuquerque, NM: Master's level psychology Intern. Co-facilitated group and art therapy.

Publications:

Olmstead, R. (2001). Case study: Treatment of chronic vocal tic disorder. *Auditory Visual Stimulation, 1*(4), 7-9.

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Presentations:

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New Non-Drug Treatment for ADD (1994).

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