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The Effect of Spatial Scale on the Variables of Attention of Eight- to Twelve-Year Old Children with Attention Deficit-Hyperactivity Disorder

Julie K. Nelson
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Julie K. Nelson entitled "The Effect of Spatial Scale on the Variables of Attention of Eight- to Twelve-Year Old Children with Attention Deficit-Hyperactivity Disorder." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Architecture.

Alton J. DeLong, Major Professor

We have read this thesis and recommend its acceptance:

Virginia W. Kupritz, Deborah Tegano

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Major Professor

We have read this thesis
and recommend its acceptance:

Dr. Virginia W. Kupritz

Virginia W. Kupritz

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Associate Vice Chancellor and
Dean of The Graduate School

THE EFFECT OF SPATIAL SCALE ON THE VARIABLES OF ATTENTION OF EIGHT- TO TWELVE-YEAR OLD CHILDREN WITH ATTENTION DEFICIT-HYPERACTIVITY DISORDER

A Thesis
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Julie K. Nelson
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ABSTRACT

This study investigated the effects of scale-reduced environments on measures of attention for children with Attention Deficit-Hyperactive Disorder (ADHD). A theory of experiential space-time relativity proposes that small-scaled spaces alter one's temporal experience which can in turn improve the efficiency of that individual's information processing. The independent variable was a scale-reduced space. The dependent variable was the Test of Variables of Attention (T.O.V.A., Greenberg, 1987). The purpose of the study was to demonstrate that a simple, harmless, drug-free intervention could improve an ADHD child's ability to attend to information and perform by altering the child's temporal experience. It was hypothesized that the ADHD children would perform better in a scale-reduced environment when compared to a larger environment.

The sample included 14 children, ages 8 to 12 years, with Attention Deficit Disorder (ADD). Eleven of the children were previously diagnosed with ADHD, while 3 were designated ADD without hyperactivity. In a counter balanced experimental design, subjects were randomly assigned to one of two groups. The groups were exposed to the two conditions (small or large space) in an alternating order to control for regression toward the mean and novelty effects. The

method of data collection was a computerized continuous performance test called the Test of Variables of Attention (T.O.V.A.). The T.O.V.A. was administered and scored by the computer.

Experiential space-time relativity theorizes that spatial scale relationships affect temporal experience, which can alter information processing. Scale-reduced environments offer assistance to all, young and old, with or without ADD. They are inexpensive, harmless, and can be available for use by all children in a classroom or home. The results of this study indicate that scale-reduced environments can provide the occasion for more efficient information processing and altered attention spans.

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INTRODUCTION

Children with Attention Deficit Hyperactivity Disorder (ADHD) are characterized as impulsive, inattentive, and hyperactive. Diagnosis has been difficult, with many physicians relying on parents' and teachers' descriptions of the child's behavior. The distinction for diagnosis has been found to be the intensity, persistence and clustering of these behaviors (Goldstein & Goldstein, 1990).

Research has shown morphological differences in the corpus callosum of ADHD patients (Hynd, 1991). Other researchers continue to search for dysfunctions of the neurochemical systems of the brain (Malone, 1994; Zametkin, 1990). Most recently, ADHD has been linked to the eleventh chromosome allele, but is also been found to be multi-genic (Blum, Noble & Sheridan, 1990). Additional research has linked ADHD to immune deficiencies (Warren et al. 1995).

Recognizing the neurological basis of ADHD is important for proper diagnosis, as well as the prescription of effective therapies. Unfortunately, as with most complex brain dysfunctions, curative procedures are not the norm. Rather, the patient must learn ways to manage and cope with their disorder. Today, it is estimated between 3-12% of the population are afflicted with some form of Attention Deficit Disorder, with or without hyperactivity. This equates to many people in need of treatments.

The symptoms of the disorder typically surface around 3 to 4 years of age. These children usually begin to have serious scholastic problems around ages 8 to 9 years. Additionally, these children may exhibit a developmental delay due to the missed learning as a result of their inability to focus on tasks and play. Some appear to "outgrow" the disorder. However, most children who are properly diagnosed will deal with ADHD throughout their life and may continuously experience frustration and developmental lags as a result of the behavioral difficulties (Blackman, 1991).

Traditional treatments for children with ADHD consist mainly of drug therapy and behavior modification. Biofeedback training has also been shown to be effective (Blanton & Johnson, 1991; Lubar & Shouse, 1979). The manipulation of spatial scale is an unexplored domain of possible intervention and is the focus of this research project. The concept of spatial scale deals with the size of the individual, relative to the size of their immediate physical environment. On the basis of a **theory of experiential space-time relativity** (De Long, 1981, 1985, 1994), a person experiences time relative to the environment that he or she is experiencing at the moment. If the person feels large relative to their environment, then their experience of time is speeded up relative to standard clock time. This temporal experience is also tied to the information processing system of the brain.

From the framework of the theory, with a decrease in spatial scale, we expect an increase in information processing and temporal experience. With this increase, it is proposed that the child's information processing sensitivity will be increased so that more stimulation from the environment will be received. In other words, in a given period of time X, physical environment held constant, a normal functioning brain will experience Y amount of stimuli. In the same time period X, the brain of the ADHD individual experiences Z amount of stimuli. Z is markedly reduced from Y.

Variables

The independent variable is the scale-reduced environment. The dependent variable is the Test of Variables of Attention. (T.O.V.A.) (Greenberg, 1987). The scale-reduced environment is hypothesized to increase the child's experience of time passing, thereby allowing the perceptual framework to focus on tasks. Therefore, it is expected that the scores will be better in the scale-reduced environment when compared to a larger environment.

Importance of this study

It is from the framework of experiential space-time relativity that a spatial intervention holds the possibility of affecting how a child with ADHD experiences time. If we can speed up the time that the child experiences by placing him or her in a small scaled environment, the child should be able to process the information necessary to engage in the more complex tasks involved in learning. A small-scaled environment is inexpensive and simple to incorporate into the every day life of the child, in either a classroom or home setting. The hypothesis holds the possibility of treatment for ADHD in combination with drug therapy. Recent concern has surfaced concerning abuse, misuse and side-effects of the commonly prescribed drugs for ADHD (Bogdanich & Jarriel, 1995; Friend, 1995). These concerns place increasing interest in the development of non-medicinal treatments.

Through an impersonally mediated environmental scale change, it may be possible to manipulate the time that the child experiences, thereby engineering a time frame in which an ADHD child can accomplish a task or become more involved in a play cycle. As a result, side effects from drug therapy could be decreased or eliminated. For the educator, contingency management procedures could be decreased thereby freeing the teacher to spend more time teaching.

Specific Aims

The specific aims of this study are to demonstrate that a simple scale-reduced environment will improve the child's ability to attend to information and perform by altering the ADHD child's temporal experience .

CHAPTER 2

REVIEW OF THE LITERATURE

History

Historically, the Greek physician Galen prescribed opium for restless, colicky infants. Physicians in the 1890's observed behavior similarities among brain-injured patients and retarded individuals with no history of trauma or injury. In 1902, looking at hyperkinesthetic individuals' inability to internalize rules and limits, George Still referred to the disorder as *a defect in moral control*. In 1918, after a world outbreak of encephalitis, some recovered children manifested a pattern of restless, inattentive, easily overaroused and hyperactive behavior that was not present before their illness. It was then hypothesized that this behavior was the result of some degree of brain injury caused by the disease. The term *post encephalitic disorder* came to label the disorder.

In 1937, Charles Bradley experimented with the use of stimulants for treating emotionally disturbed children. World War II presented many opportunities to study head trauma. Researchers found that injury to any part of the brain frequently resulted in a pattern of inattentive, restless and overaroused behavior. This finding gave support to the idea that children with this pattern of behavior might have been victims of some form of brain damage or dysfunction. *Minimal Brain Dysfunction* became the "new" term for the disorder (Goldstein & Goldstein, 1990).

Strauss and Lehtinen (1947) then hypothesized distraction to be the main problem for these children. On the basis of this hypothesis, some proposed a minimal stimulation classroom in which teachers wore drab colors, classroom walls had no decoration and classroom windows were frosted. The development of special curriculum was also instituted. Research literature failed to show that this type of intervention provided any benefit to these children (Goldstein & Goldstein, 1990).

By the 1970's the shift was away from believing the core problem was excessive activity. The belief was toward viewing ADHD as a problem of inattention. This led to a major shift of focus in research, diagnosis, and intervention.

Definition

At the present time, symptomatology is based on presenting behaviors although researchers are currently finding neurological explanations for the disorder. The DSM-III-R definition is currently the clinicians guide to diagnosis. This definition is contained in the *Diagnostic and Statistical Manual* of the American Psychiatric Association (APA, 1987). The definition includes fourteen behaviors that the child may exhibit. Each criterion (separate behavior) is met only if the presupposed ADHD child exhibits the behavior more frequently than most children of the same mental age.

Goldstein and Goldstein (1990) give several definitions of ADHD. The "common sense definition" describes ADHD children as inattentive, distractible, overaroused, impulsive and having difficulty delaying gratification. Their more precise, theoretical definition of the attentional processes explains attention as a "generic term used to designate a group of hypothetical mechanisms that collectively serve to narrow the scope and focus of information to be processed and assimilated" (p. 13). Thomas (1992) concurs that central to the information-processing theory are the phenomena of attention, perception and memory.

Significance of Diagnosis

Children with ADHD may have several different types of attention problems. They may manifest behaviors covering a broad range of attentional processes. Some may have difficulty accomplishing tasks that are required simultaneously, such as listening to the teacher and taking notes. This process is termed *divided attention*. Many ADHD children are easily distracted by minor noises or movement in the classroom. For them, it is difficult to select the most important stimuli to which they must attend. This process is termed *selective attention*. Problems with *persistence* or *sustained attention* are shown by an inability to stay on task long enough to satisfactorily complete the task. *Focused attention* is often the hallmark of ADD without hyperactivity. These children are often accused of being daydreamers who do not pay attention to the essential elements of classroom mechanics such as an assignment given verbally by the teacher (Goldstein & Goldstein, 1990).

In addition to these attention deficits, on the surface, ADHD children may appear demanding, self-centered, lazy and rude. They are often criticized by adults and avoided by their peers. Due to the impulsive nature of the disorder, these individuals tend to be risk-takers who neglect appropriate consideration for outcomes or consequences. Hyperactive individuals are characterized by an inability to sit still, frequently tapping their fingers or toes and fidgeting. They do not respond well to traditional teaching methods. They respond positively to one-on-one contact, small groups and small classroom spaces (Barkley & Dawkins, 1992; Lubar, 1994).

As a result of these behavior problems, the individual with ADHD may suffer in the social, emotional and cognitive areas of development. Some of the social and emotional problems include anxiety, depression, conduct disorders and opposition. Learning problems may be in the area of language, memory, auditory processing and achievement. Cognitive deficits may include slow information processing, difficulty with flexible thinking and problems forming concepts. Goldstein & Goldstein (1990) reported several studies revealing that incidences of anti-social activities and school suspensions were roughly thirty percent higher for ADHD adolescents than for those adolescents without ADHD. In addition, academic delay was seventy percent higher for ADHD adolescents than for their non-ADHD counterparts.

The severity and variety of problems faced by the ADHD child magnify the importance of early and accurate diagnosis along with early, appropriate, and effective interventions.

Recent Research on the Neurological Basis of ADHD

Researchers have investigated neuroanatomical, neurochemical, and neurophysiological systems in an attempt to understand the etiology of ADHD. Hynd (1991) has found preliminary evidence of differences in corpus callosum morphology, as measured by Magnetic Resonance Imaging (MRI), in ADHD children when compared to controls. The areas of the corpus callosum believed to relate to inhibition, motor regulation, and motor persistence were smaller in the ADHD children.

Other researchers (Malone, 1994) have investigated the role of specific neurotransmitters believed to carry communication through the neuronal circuits that are implicated in ADHD. It is believed by some that decreased dopamine and increased norepinephrine neurotransmission are possible underlying symptoms. Stimulant medications have been found to modify these neurotransmitters.

Positron emission tomography (PET scans) has shown reduced brain glucose metabolism in adults with ADHD (Zametkin, 1990). This reduction may relate to the areas in the brain that govern response inhibition, attention, and sensitivity to reward (Barkley & Dawkins, 1992).

At present, there is no consensus as to definitive cause of ADHD. However, studies such as these are beginning to pave the way towards explanatory elements that may circumscribe the most therapeutic intervention. Malone (1994) stated that contextual factors affect the manifestation of the disorder on a situational basis. Consideration of contextual factors seems to necessarily complicate the analysis of efficacious therapies and must be addressed.

Current Therapies

The main therapy treatment options for Attention Deficit-Hyperactivity Disorder include drug therapy, behavior modification, and biofeedback training (Barkley, 1981; Goldstein & Goldstein, 1990; Lahey, 1979). There have also been suggestions to rearrange classroom environments in an effort to control the amount of distractions reaching the child (Brundage-Aguar, Forehand, & Ciminero, 1976; Goldstein & Goldstein, 1990). Treatment efforts that have failed include diet management, vitamin therapy, sensory-integration training, and chiropractic manipulation.

Drug Therapy

Three main categories of drugs are most commonly prescribed for the ADHD individual. These categories include stimulants, anti-depressants, and anti-hypertensives. It is estimated that 80% of children diagnosed with ADHD are prescribed the stimulant methylphenidate (by the trade name of Ritalin) or dextroamphetamine (trade name Dexedrine or Cylert). This brings the total number of U. S. school children taking stimulant medication to near 750,000 (Black, 1992). When a child is on the medication, they appear calmed. Nevertheless, the actual effect of the drug is an "enhanced alertness". This enhanced alertness enables the child to focus their concentration, thereby increasing attention span (Snyder, 1974).

Anti-depressants, such as Imipramine or Desipramine may be prescribed when mood problems such as aggression accompany the disorder and stimulants have not been effective. However, anti-depressants cannot be used as long term therapy because arrhythmia and tachycardia are possible side effects.

Tricyclic alpha-blockers, such as Clonidine have also been prescribed for ADHD. These anti-hypertensive types of drugs help to decrease aggressive behavior and increase attention, although they have not been as effective as stimulants. Recently, use of Clonidine has come under fire by opponents who insist that the drug has not been sufficiently tested under scientific conditions. These opponents assert that Clonidine has been responsible for heart problems and even death among ADHD children (Friend, 1995).

As a form of therapy, the most commonly prescribed amphetamines do not cure the child. They offer relief only while the child is taking the drug (Lubar, 1994). Some children experience side effects from the medication in the form of anorexia, insomnia, irritability, motor tics, or stomach aches (Blackman, Westervelt, Stevenson, & Welch, 1991). These instances, although commonly mild, do not appear to be that uncommon, as evidenced by the number of children who forego their medication over the summer. Hence, an individual decision must be made as to the effectiveness of drug treatment (Goldstein & Goldstein, 1990).

These drugs are categorized among the most highly regulated medications. Recently, several problems associated with their misuse and abuse have surfaced. Bogdanich & Jarriel (1995) have reported that Ritalin has become "the poor man's cocaine." The report stated that Ritalin has been stolen, bought, and sold by teachers, pharmacists, parents, and siblings of children legitimately using the medication for their disorder. These concerns place renewed emphasis on interest in non-medicinal treatment forms.

Behavior Modification

The behavior modification approach includes many different training procedures and may include an educational management program. Some of the specifics include institution of a time out and reward system where remediation is clear, specific, and timely, happening directly after behavior. Giving positive attention, affection, and verbal praise is also an integral part of behavior modification. The training is directed mainly at the child with ADHD, but training programs have also been developed for parents and teachers of the ADHD child. Counseling parents helps them understand the disorder, change their expectations, and learn to build the child's self-esteem. They are trained how to modify the child's environment and develop a "game plan" for behavior in public places (Barkley, 1981; Lahey, 1979; Purvis, Jones & Authement, 1992).

The effectiveness of behavior modification is also much debated, with recommendations made for a multi-modal treatment approach. A multi-modal approach combines the treatments of drug therapy with behavior modification training. Research has shown the multi-modal approach to be somewhat effective as an intervention (Goldstein & Goldstein, 1990; Purvis, Jones & Authement, 1992; Richters et al. 1995).

Biofeedback Training

Children trained to use biofeedback techniques were able to consciously lower their own electromyographic (EMG) activity, the result of which is believed to increase attention to task. In the same study, one of the subjects was observed in the classroom as well in order to assess transfer of the learned technique. The subject did experience an increase in on-task behavior in the classroom (Blanton & Johnson, 1991).

Lubar and Shouse (1979) describe central nervous system (CNS) arousal as a measurable symptom in ADHD children, dividing them into two subgroups of reduced and heightened CNS arousal. This arousal is measured through brain-wave (EEG) activity. The emphasis of biofeedback training is placed on the behavioral control of a rhythm, or sensorimotor rhythm (SMR), that is recorded over the sensorimotor cortical regions of the human brain. Results indicated that effectively learning the SMR task contributed to substantial improvement either in combination with drug therapy or without the use of medication. Behavioral benefits were also assessed through classroom observations. Results indicated that ADHD subjects with low CNS arousal decreased undesirable behaviors such as self-stimulation, object play, and being out of their seat, while increasing desirable behaviors such as staying on task, cooperation and eye contact.

Cartozzo, Jacobs and Gevirtz (1995) trained fifteen 6-11 year old ADHD children to decrease theta amplitude (4-7 Hz) through thirty 45-minute EEG biofeedback sessions. The results indicated an increase in capacity to sustain attention and concentrate. A similar study revealed that 8-12 year old ADD children made significant gains in performance on the Test of Variables of Attention (T.O.V.A.) after forty-eight sessions of neurofeedback therapy (Scheinbaum, Newton, Zecker & Rosenfeld, 1995).

Recently, the effects of neurofeedback training on children with ADHD were assessed through both objective and subjective measures. Lubar, Swartwood, Swartwood, & O'Donnell (1995) defined neurofeedback as a "form of biofeedback linked to a specific aspect of the electrical activity of the brain such as the frequency, location, amplitude, or duration of specific EEG activity" (p. 84). The study involved 23 children, ages 8 to 19 years, in intensive neurofeedback training sessions over a 3-month period. The objective was to correlate the successful decrease of the subject's theta (slow) activity in the EEG to two objective measures (the T.O.V.A. and the WISC-R) and one subjective measure (behavior ratings).

After approximately 40 neurofeedback training sessions, subjects completed the T.O.V.A and WISC-R and subjects' parents completed the behavior ratings. Results indicated that the subjects who made a change in their EEG pattern also made improvement on 3 out of 4 scales of the T.O.V.A. All subjects who improved their EEG pattern also improved their IQ scores on the WISC-R. Behavioral ratings improved for all subjects, including those who did not significantly improve their EEG patterns. This result was explained as a problem with subjective measures. The investigators hypothesized that the parents "over-emphasized" their child's progress as a result of involvement with a treatment program, regardless of amount or type of treatment received.

Environmental Manipulation

Some studies suggest environmental manipulation to decrease visual and vestibular distractions. (Barkley, 1981; Black, 1992; Clawson, 1992; Purvis, Jones, & Authement, 1992). While these measures appear to have face validity, results are inconclusive as to whether these minimal environmental manipulations assist the ADHD child.

Hooper and Reid (1985) incorporated use of a portable "distracter shield" to assist profoundly retarded adult subjects to increase attending or on-task behavior. In 3 out of 4 cases, attending behavior was increased with use of a distracter shield.

This study as well as others on this topic, have assumed that hyperactivity results from excessive environmental stimulation (Bower & Mercer, 1975; Glennon & Nason, 1974). By contrast, others believe a different mechanism is at work; that the brain is functioning more slowly than normal. This means, therefore, that minimal stimulation is reaching the brain, and the hyperactivity is a result of the search to fill the need for external stimulation (De Long & Lubar, 1979; De Long et al. 1994; Lubar, 1994; Meade, 1991; Snyder, 1974).

Recently, manufacturers of office furniture have begun to address the need for worker's focused attention in an open workplace (Zelinsky, 1994). A compact "workspace" has been designed by more than one manufacturer that resembles the design of an automobile, airplane cockpit, or space shuttle. The workspace was designed to allow a way to shut out distractions and increase worker productivity. These compact workspaces have been reported to be popular among workers using the spaces (Brill, 1995).

Relationship between the Phenomenon of Time and ADHD

Several studies indicate a contextual relationship between attentional processes and temporal perception. Denber (1986) proposed that the passage of time is an internal phenomenon, or a function of one's relationship to the external world. This temporal passage "appears" to slow down in individuals with psychiatric disorders such as schizophrenia. This slowing effect permits an overabundance of stimuli to reach the schizophrenic's nervous system and results in sensory overload. Often, individuals with this type of disorder seek solitude and quiet environments. By contrast, the hyperactive individual seeks out stimulation and "noisy" environments (Snyder, 1974). It appears that somehow the excess stimulation fills in the deficits of slow information processing, forcing the hyperactive individual to focus (Lubar, 1994).

Denber (1986) continued to explain time as "either an external event linked to surrounding space, or, when internalized, an indicator of cerebral function" (p. 213). Anyone who has waited for a pot of water to boil has experienced the "watched pot never boils" phenomena. Zakay (1992) proposed a model of attention that views time estimation as a mechanism directly related to the amount of attention given to processing the passage of time. He explained the "watched pot phenomena" as a function of the amount of attention given to waiting, resulting in a lengthening of temporal duration.

Zakay (1992) asserted that attentional factors have a crucial impact on children's reasoning about time. He proposed that "prospective" time estimates (those in which the subjects knew they would have to estimate time before the task began) would be longer than "retrospective" time estimates (those in which the subjects were asked to estimate how much time had past after the task was completed) of seven- to nine-year old children. Results were significant in support of the hypothesis. Prospective time estimates were explained as a function of attentional processes. During "prospective" conditions more information was being processed simultaneously. Retrospective time estimates were postulated as a function of memory and sensitive to contextual effects.

In a second experiment, the subjects were distracted during the task, in both the prospective and retrospective time estimation conditions. Estimations decreased in all groups, again demonstrating the relationship between attentional focus and accuracy of time estimation.

Cappella, Gentile, and Juliano (1977) found that eight- to twelve-year old hyperactive children made larger errors of time estimation than normal children and that the longer the interval to be estimated (7, 15, and 30 seconds), the larger the error. Hence, ADHD children have increased challenges dealing with time. This may be explained by the impact that contextual effects or external events have on time estimation as well as by the relationship of temporal duration and information processing.

Experiential Space-Time Relativity

The theory of experiential space-time relativity is based on the conceptual framework of Environmental Psychology, which asserts that to fully understand the psychology of the individual, the individual must be considered with its environment, that the two are inseparable, the environment is ever present (Altman & Christensen, 1990; Gibson, 1991; Proshansky, Ittelson & Rivlin, 1976).

Gibson (1991) proposed that the concept of attention is manifested from birth when an infant expresses interest by attending to particular objects over others. As the infant matures, attention is given to objects external to themselves if the object is "reachable." Thus, a concept of scale relationships and distances begins to develop. He further proposed that scale relationships are fundamental to the animal kingdom as well. One can observe the toad as it perceives and attempts to enter only into spaces large enough to allow passage for their body size. A toad also attempts to seize only prey that is small enough to allow the toad to successfully dominate in terms of its larger body size. Careful thought and examination of these phenomena gave rise to the idea that scale relationships are a fundamental aspect of the information processing system, forming the basis upon which animals and humans alike make decisions about acting upon their environment.

Relying on this framework, De Long (1981) exposed subjects to scale models of three different sizes. Subjects were asked to familiarize themselves to the environment and imagine themselves in the scale model environment, waiting for a friend. Subjects were then instructed to inform the investigator when they felt subjectively that thirty minutes had elapsed. Results indicate a proportional compression in temporal experience and scale of space relative to a clock on the wall and a full-size environment. For example, while observing the model 1/6th of actual size, the subjects felt that 30 minutes passed in 5.5 minutes. While observing the 1/12 model, 30 minutes was experienced in approximately 2.5 minutes of elapsed time. Likewise, while observing the 1/24 model, 30 minutes was experienced in approximately 90 seconds.

To check this phenomenon, another experiment was conducted with 15 adult subjects performing a variety of activities in a normal-sized environment. Temporal cues, such as clocks, were removed from the environment. The actual elapsed times ranged from 2 minutes to 3 and a half hours. The subjects were asked to make retrospective time estimates of the amount of time that had passed from a specific behavioral event during the session. Seventy-seven observations were made. The subjects estimates in the full-size environment were close to actual elapsed time, with estimated time of 35 minutes when actual time elapsed was 30 minutes.

This phenomenon gave rise to the formulation of the relationship as E=x(T), where x is the reciprocal of the scale of the environment being observed, E is the experienced time, and T is the actual time as measured by a standard clock (De Long, 1981).

A similar experiment was performed with subjects playing video games on two different sized monitors, a 7" screen and a 23" screen. The subjects scored more points on the smaller monitor in less time than when playing on the larger monitor. Their performance was 12-15% better when playing on the small monitor. These subjects were also asked to estimate how much time had passed. The subjects felt that games played on the smaller, 7" monitor were longer, when in actuality they were significantly shorter. (De Long, 1985). Hence, the scale relationship of a person to his/her immediate environment (here it is the size of the video screen) is again demonstrated to have a significant effect on information processing.

Exploratory latencies in lizards in novel environments were also examined as a function of spatial scale, thus identifying this phenomenon as fundamental to perceptual processes (De Long, Greenberg & Keaney, 1986).

An application of this theory in the natural environment was tested by measuring the effect of spatial scale on complex play cycles in preschool children. Here, the scale-reduced structure resembled a screened porch, 7 feet long by 5 feet wide by 5 feet high. Screen was used to allow visual and auditory access of the children to their surroundings and by the teachers in the room as well as the observers. De Long et al. (1994) found that "subjects enter complex play more quickly, engage in play segments of longer duration and tend to spend a slightly greater percentage of their overall play time in complex play" (p. 13).

If these children were able to enter complex play more quickly, perhaps children with ADHD could benefit from a chance to participate in complex forms of play. Since entering complex play is a function of time, ADHD children may not normally stay engaged long enough to enter a complex play cycle.

Another method of manipulating the perception of scale in the natural environment was investigated by Brickey (1994). Scale was manipulated through background pattern designs in the peripheral vision of preschool children. Large and small scale patterned carpets were placed alternately around an existing play area in a preschool setting. The mean play segment lengths were recorded as a measure of attention span in the subjects. These play segments were observed to increase under small scale pattern conditions.

It is from the theoretical framework of experiential space time relativity and the results of related studies, that the possibility of manipulating spatial scale becomes of interest as a possible intervention for children with ADHD. The ability of scale relationships to increase the amount of information processed seems to parallel the effect of stimulant medications, without the adverse side effects.

The Neurology of ADHD and Reduced Environmental Scale

Electroencephalography (EEG) studies have documented substantial differences between EEG's of ADHD patients and normal EEG's, particularly with theta activity (4-8 Hz). ADHD's show a substantial increase of theta (slow) waves and these theta waves occur more often than in those of normal EEG's. Theta waves are associated with daydreaming, falling asleep, and inability to concentrate or focus (Lubar, 1994).

Research on the effect of scale-reduced environments on EEG output has shown that, 1) absolute power output was increased across all spectral ranges, and, 2) a selective increase in percent power was shown among the higher frequencies (16-27 Hz) (De Long & Lubar, 1979). These higher frequencies correlate with beta waves, which are typically 14-35 Hz. Beta waves are associated with concentration, focusing, and attending mechanisms (Lubar, 1994). Thus, the scale-reduced environments serve to amplify the information received by the brain. The brain apparently becomes more sensitive to incoming information (De Long, 1994).

The results of the EEG study appears to give strength to the theory that a scale-reduced environment holds the possibility of increasing the quantity of beta waves and decreasing the amount of theta waves. Since the quantity of these frequencies is a documented aspect of the ADHD disorder, there is support for the proposed reduced-scale environmental manipulation as a treatment for children with ADHD. Recently, Swartwood (1994) documented the stimulant Ritalin as having little effect on EEG output. Since biofeedback training has also been shown to improve EEG output simultaneously to certain desirable behaviors (Lubar & Shouse, 1979), the scale-reduced environment becomes of great interest for its role in affect on the information processing system in the brain.

CHAPTER 3

METHODOLOGY

The study was designed to assess if there is a difference in the variables of attention of eight- to twelve- year old children with attention deficit disorder in large- and small-sized rooms. The study hypothesizes that the subjects will perform better in the small-sized environment.

Method

Sample

Subjects. The subjects were volunteers whose parents agreed to let their children participate in the study. Subjects were 14 children with Attention Deficit Disorder (ADD), ages 8 through 13. At the time of the first testing, the youngest child was 8.6 years and the oldest child was 13.3 years, with the mode at 12.66 years and the mean at 11.35 years. The 8 through 12 age group was chosen because this is the age at which the children typically begin to experience serious scholastic problems. They also could be categorized into Piaget's concrete operational period (Thomas, 1992). There were 10 males with a mean age of 11.45 years and 4 females with a mean age of 11.08 years. Most participants were expected to be male as there is a markedly high percentage of males diagnosed ADD with or without hyperactivity compared to females.

The subjects were previously physician diagnosed as having ADD according to DSM-III-R criteria (APA, 1987). Subjects were also free from other serious psychiatric or medical conditions. Eleven of the subjects (all of the males and one of the females) had the diagnosis of Attention Deficit Disorder with Hyperactivity, while three (all females) did not have the hyperactivity designation in their diagnoses.

The subjects may or may not have been on a medication schedule. Their schedules included some of the commonly prescribed drugs for the disorder. Of those eight subjects whom were on a medication schedule at the time of testing, five had taken methylphenidate or Ritalin, two had taken dextroamphetamine or Dexedrine, and one had taken an anti-depressant known as Imipramine. Four of the six subjects who were not regularly taking medication during the testing period, did take methylphenidate during the school year. The remaining two subjects did not take medication for ADD at any time of the year.

The subject's regular medication schedule was not interrupted. The investigator attempted to test the subject not less than 4 hours after they last took their medication in an effort to allow the medication to have left their system. Eight of the subjects were on a regular medication schedule during the period in which the testing situations occurred. The interval from the time the last dosage of medication was taken until the testing occurred ranged from 1 hour to 9.25 hours, with a mean of 5.7 hours. Table 1 is a listing of individual subject's medication type and the dosage-to-testing interval.

The testing sessions occurred as close to 4:00 p.m. as possible, in an effort to hold diurnal effects constant. In 10 out of 14 cases, the testing occurred within 2 hours before or after 4:00 p.m. In 4 cases, the testing occurred between 9:30 and 11:00 a.m. In all cases the time of the testing for each individual subject was kept as constant as possible across the two conditions. There was a range of 1 to 28 minute difference in the testing times from condition A to condition B, with the mean at 9 minutes.

Table 1. Time interval from last medication dose until testing session.

Gender	Medication Type	Interval - Small (hrs.)	Interval - Large (hrs.)
M	Ritalin	6.5	6.5
M	0 in summer	no med	no med
M	0 in summer	no med	no med
M	0 in summer	no med	no med
M	Methylphen	7.5	7.5
M	Ritalin	no med	no med
M	Ritalin	8.75	4.5
M	Imipramine	1	1
M	Dexedrine	6.25	5.5
M	0 in summer	no med	no med
F	Ritalin	9.25	9
F	none		
F	Dexedrine	6.5	6.5
F	none		

Experimental Design

A counter balanced experimental design was used to control for some validity problems inherent to this study. The subjects were randomly assigned to group one or group two and served as their own controls measured under both conditions. The research hypothesis states that the small environment will improve the measures of attention. Hence, both groups one and two were exposed to both conditions, but in a different order. Group one, consisting of six subjects, was tested in condition A first and then in condition B. Group two, consisting of eight subjects, was first tested in condition B and then in condition A. This alternation of conditions was implemented to control for practice or order effects and regression toward the mean because regardless of the order of exposure, the hypothesis states that the small environment should yield better test results than the large environment.

Setting

The data was collected in an office in the Jessie Harris Building on the University of Tennessee, Knoxville campus. Both conditions occurred in the same office. The overall size of the room was 22' wide x 16' - 6" deep x 9' -6" high. Figure 1 shows the floor plan of the office with the locations of both the large and small structures indicated.

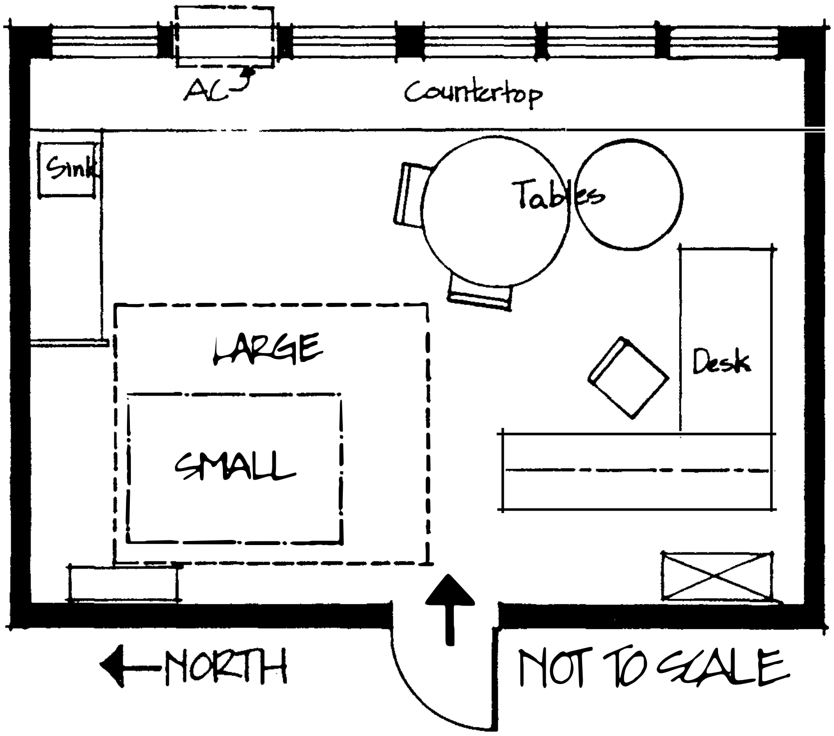

Figure 1. Floor plan of testing room with indications of locations of small and large structures.

Conditions

Condition A - Scale-reduced structure. The scale-reduced structure was built to accommodate a mean height of 4'6" to 5' for the 8 to 12 age group. The size was similar to that of the interior of a small car. It was constructed of 4-ply cardboard. The dimensions were 50 inches wide by 60 inches deep by 51-1/2 inches tall. The doorway was 36 inches wide by 48 inches high. The window cutouts were 18 inches high by 42 inches wide. They were located 12 inches from one end of the structure and 27 inches above the floor line. There was one window on each side of the structure. The goal was to make the structure practical, inexpensive, flexible, and safe. Plate 1 shows the scale-reduced structure in place in the testing room.

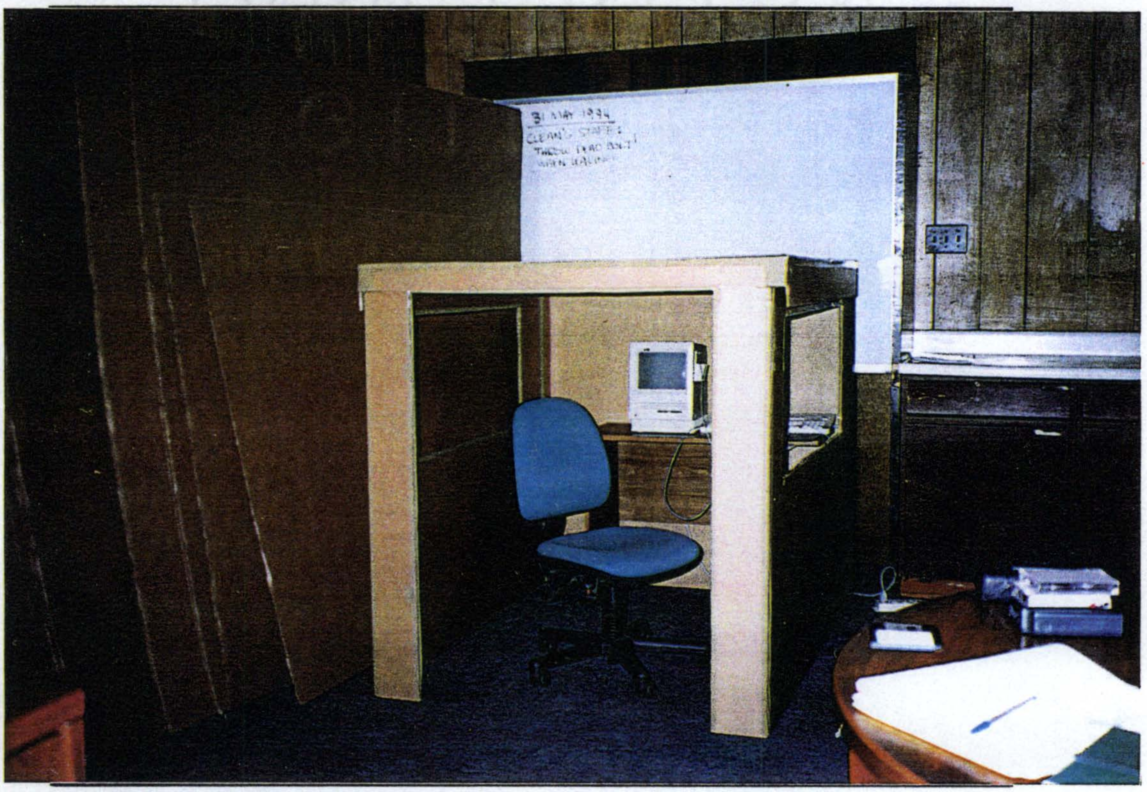

Plate 1. The scale-reduced structure as placed in the testing room.

Condition B - Large structure. The large-sized environment was 1.75 times larger than the scale-reduced structure with the measurements of 7' - 0" wide x 8' - 10" deep x 7' - 6" high. The overall design was identical to the scale-reduced structure, with the size of the window and door openings being held constant. The structure was placed in the same testing room and at the same location as the scale-reduced structure as shown in Figure 1. Plates 2 and 3 show the large structure in place in the testing room.

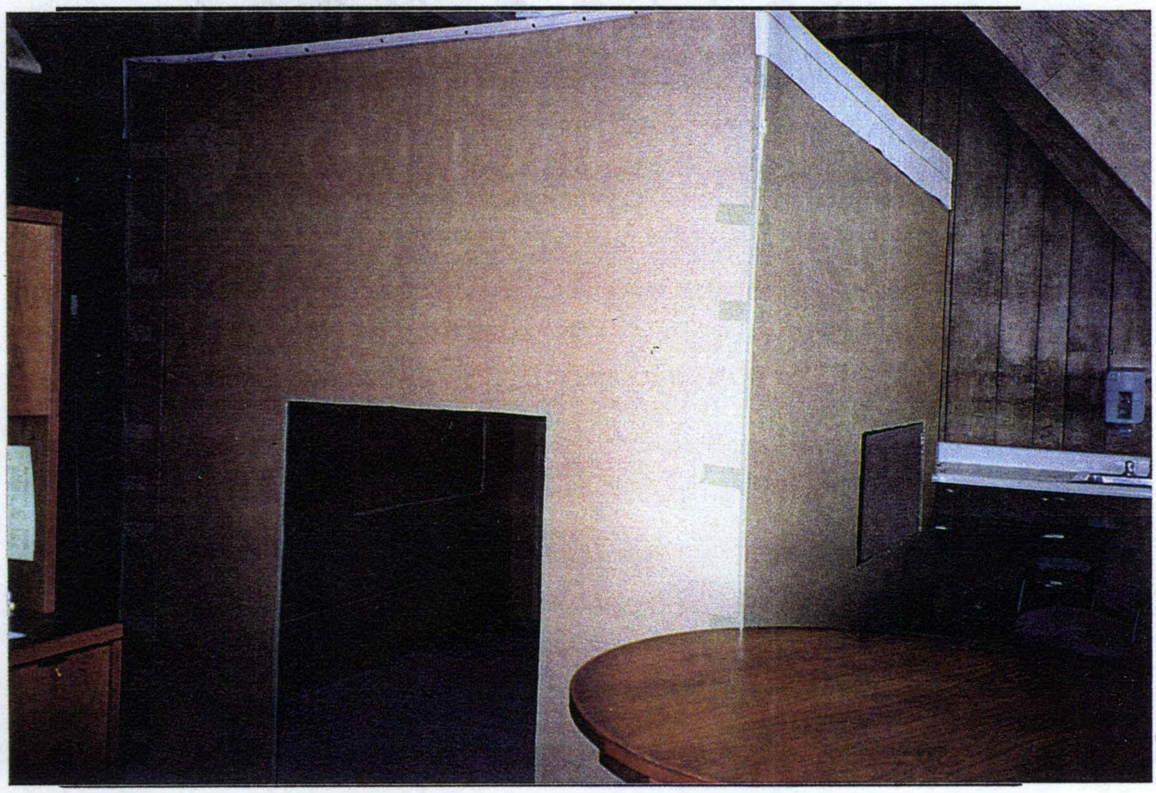

Plate 2. View of large structure in place in the testing room.

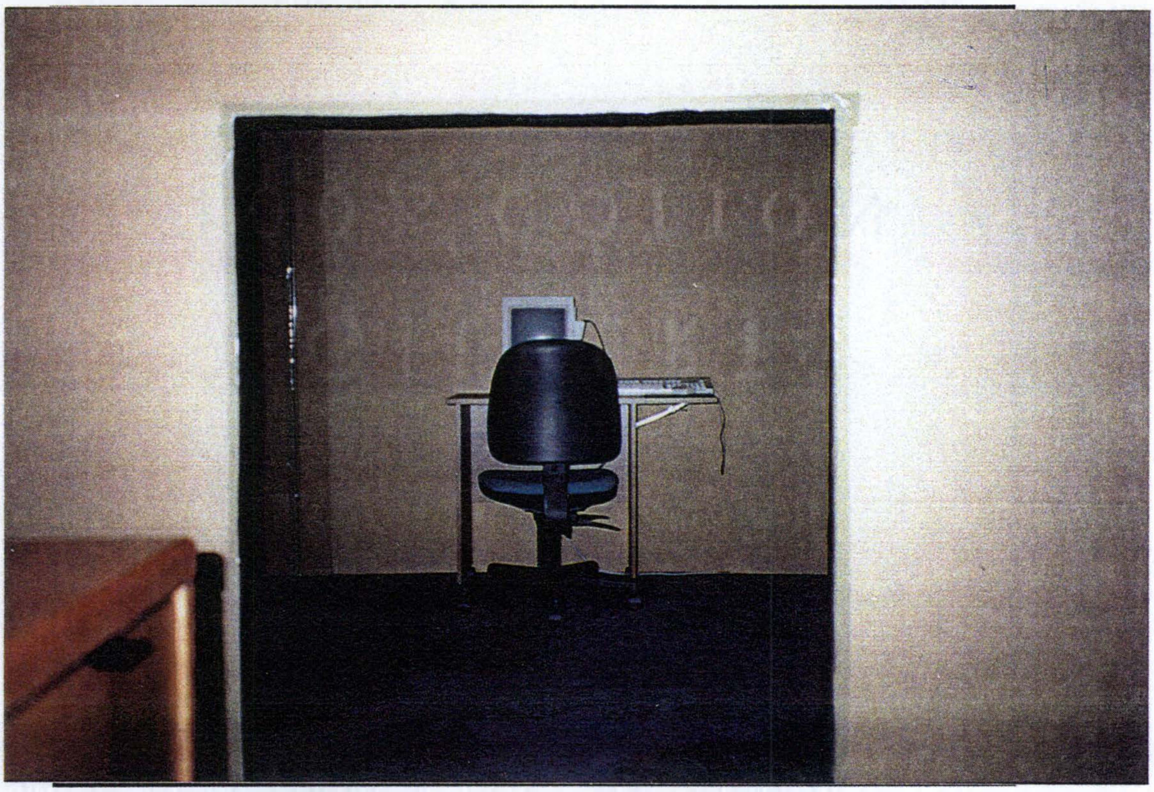

Plate 3. View of interior of large structure, showing furniture placement.

The window openings were placed in the same locations relative to the seated position of the subject in the structure. This allowed control for distractions to remain constant across the two conditions. Plates 4 and 5 show the view through the windows in both the large and scale-reduced structures.

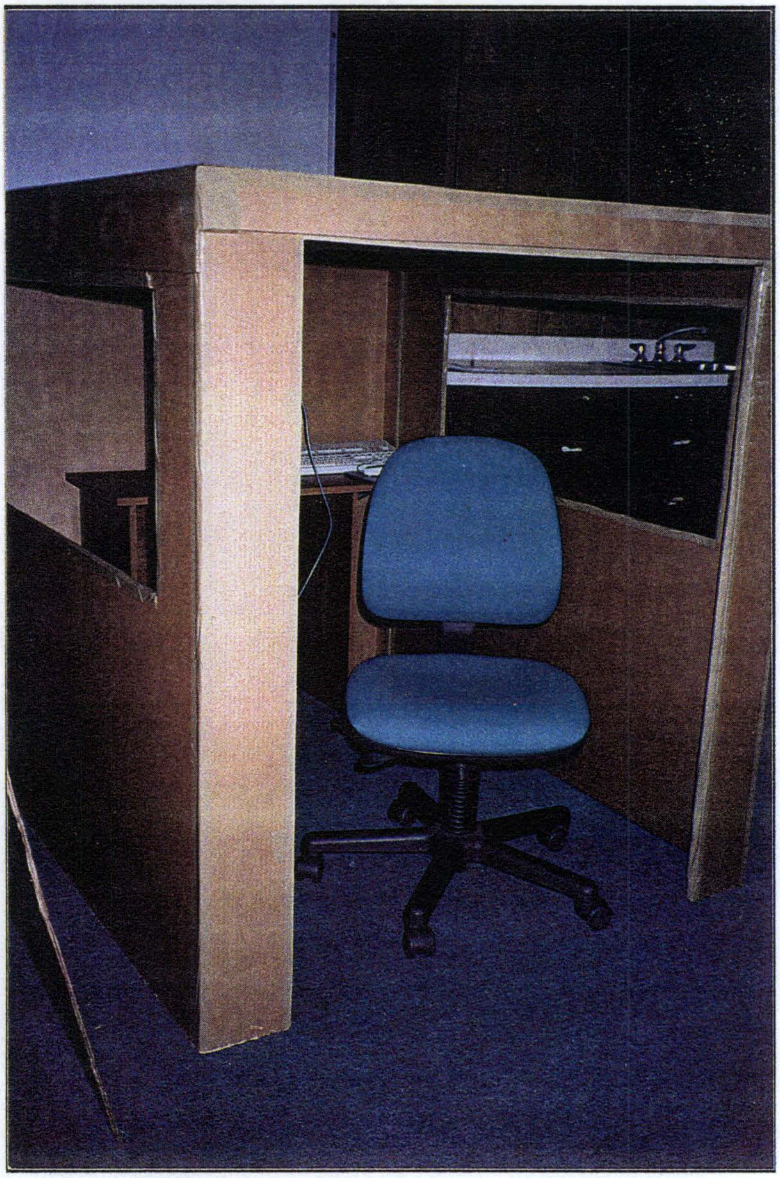

Plate 4. View of scale-reduced structure, showing view through window.

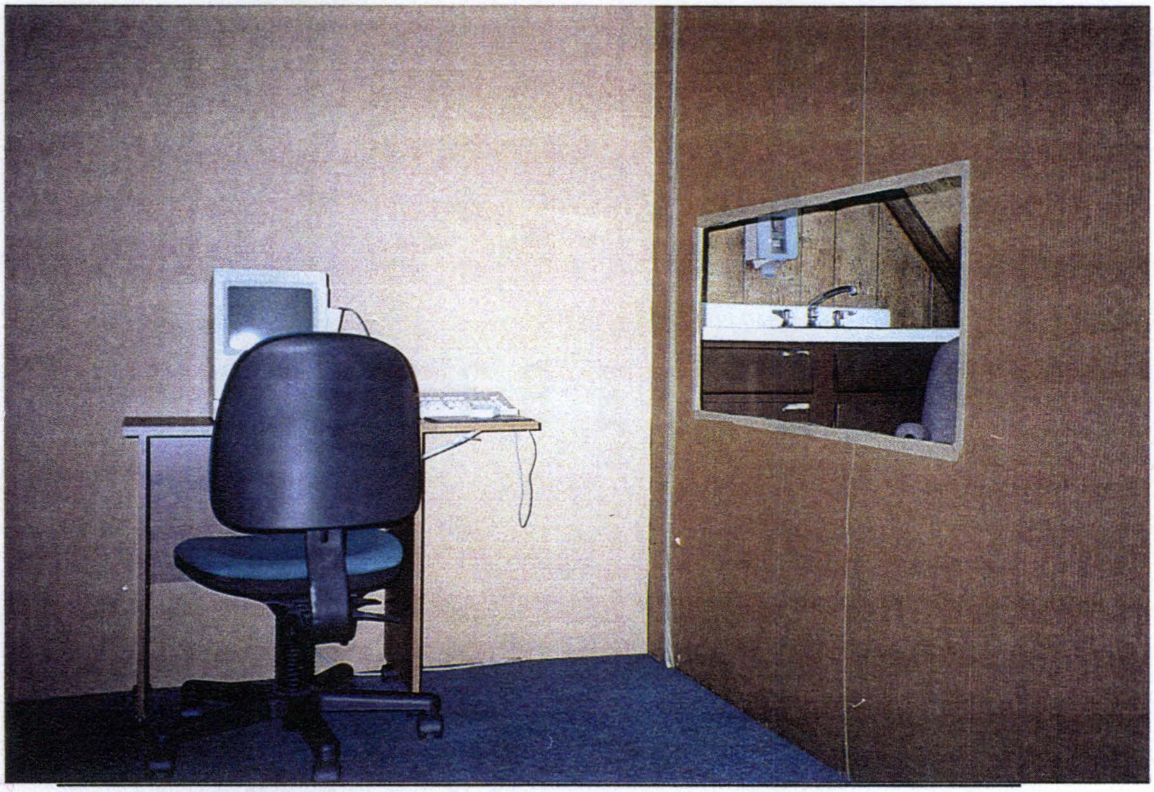

Plate 5. View of interior of large structure, showing view through window.

Furniture. A 26-1/2 inch high table was used to support the computer. A standard desk chair on a swivel base with wheels and a 15 inch seat height was provided.

Equipment. The T.O.V.A. was administered on a Macintosh SE computer.

In an effort to control for novelty effects of the structures and the testing room, the subjects were encouraged to become familiar with the room and the structures by looking and walking through the testing room and the structure before the testing began.

The length of time between testing sessions for each subject ranged from 12 to 48 days, with a mean of 25 days.

Measures

Instrument. The subjects were given the Test of Variables of Attention (T.O.V.A.) (Greenberg, 1989) in each condition.

Test of Variables of Attention (T.O.V.A.) The T.O.V.A. is a computerized visual continuous performance test, designed for use in the diagnosis and treatment of children and adults with attention disorders. During the 22.5 minute test, a random series of white squares individually flashes on the computer screen. The square is always at the same place on the screen but has a "hole" in it. This "hole" looks like a small black square within the larger white square. The location of the "hole" is that to which the subject is asked to attend. The "hole" randomly alternates between the top and bottom part of the larger white square each time the square flashes on the screen. The "target" is when the "hole" is located at the top of the square. The "non target" is when the "hole" is located at the bottom of the square. The subject is asked to press a button once every time they see the "target" flash on the screen. This button is connected to the computer and measures several variables pertaining to the response.

There are four main variables computed on the T.O.V.A. These include errors of omission, errors of commission, mean correct response time, and variability. *Errors of omission* are interpreted as a measure of inattention. *Errors of commission* are interpreted as a measure of impulsivity. *Mean correct response time* is measured in milliseconds and is interpreted as a measure of information processing and response time. The standard deviation of the mean correct response time is a measure of variability or consistency of performance. In the T.O.V.A., the standard deviation is termed *variability* (Greenberg, 1993b).

Variability is the most important variable in correlating the T.O.V.A. response and attention deficit disorders. Many children with ADD are able to sustain attention for a limited period of time. However, they are usually not able to sustain that attention consistently over time. The 22.5 minute length of time picks up on the inconsistency in response times and that variability or "extreme swings in performance have begun to be viewed as the hallmark of attention deficit disorders" (Greenberg, 1993b).

The nature of the test changes from the first half to the second half. In the first 11 minutes of the test, the target: non target ratio is 1:3. This condition sets the occasion for boredom and was designed to measure attention. The second half of the test presents a target: non target ratio of 3:1. In this condition, the subject gets into a rhythm of response and then must inhibit their response when the non target appears. This second half of the test was designed to measure impulsivity or disinhibition.

Accuracy of the T.O.V.A. has been documented. Greenberg & Crosby (1992) used the T.O.V.A. to correctly classify 89% of ADD cases and 90% of non-ADD cases. T.O.V.A. response significantly improved for ADD children responding to methylphenidate (Greenberg, 1987).

This improvement was observed while the children had the medication in their systems and manifests that the T.O.V.A. is sensitive to treatment. Greenberg (1987) also reported no test-retest practice effects, although there is somewhat of a novelty effect in that the scores on the second administration of the T.O.V.A. are expected to worsen due to boredom. For this experiment, alternating exposure to treatment conditions was the control for novelty effects.

Testing procedure. Each subject was able to practice for 2.5 minutes on a separate practice test before they began the actual test. The practice test results were then reviewed to check the subject's understanding of the instructions. The crucial variable at this point was anticipatory errors. Anticipatory errors occur when the subject "guesses" or presses the button before the stimulus has appeared on the screen. Anticipatory errors are considered a measure of reliability. If the subject had excessive anticipatory errors on the practice test, they were again instructed not to press the button until they had seen the stimulus flash on the screen. Two subjects had excessive anticipatory errors (>10% in one half) in either of their tests. Those results were not included in the data for analysis.

Scores on the T.O.V.A. were used for comparison between the sessions for individual differences. The threat to internal validity of instrumentation was controlled by the specific measures chosen. The T.O.V.A. was administered and scored by the computer. The initial instructions were given verbally by the principal investigator. These instructions were the same that were given to the subjects used to create the norming database. (The verbiage used to give the instructions is provided, see Appendix A). The initial practice session and test were then completed on the computer. There is little chance of error in the compilation of these results because they were compiled by the computer.

Procedure

Pre-Arrival of Subject. The investigator scheduled an appointment with the subject's parent. Each parent was sent a confirmation letter, with a map and a parking pass. Flyers indicating directions to the testing room were placed throughout the building.

Data collection took place throughout the summer months of June through September. Since testing took place during the summer, the building was very quiet and there were no disruptions during the testing sessions. In the testing room, an air conditioner positioned in a window was turned on during all sessions. The air conditioner served to keep the room at a comfortable temperature and the noise created by the air conditioner served to create a "white noise." This background noise also served to muffle the noise of the street traffic, and occasional sounds of ambulance sirens that could be heard from the busy street outside the building.

The light in the room came from several different sources. The artificial light came from an under counter light on the large desk in the room. This light was fluorescent and mostly illuminated the desk top. Natural light was provided by six windows with an eastern exposure in the room. Each of the six windows was equipped with adjustable venetian blinds. The blinds were shut on the three windows on the side of the room where the structures were placed. On the opposite side of the room, where the investigator sat and consent forms were signed, the blinds were adjusted to allow some light in. Overall, the room was not bright, allowing the major source of light in the structure to come from the computer screen. This was done to replicate the testing conditions of the norming sessions (Greenberg, 1993c).

Before the subject arrived, several preparations were made. First, the T.O.V.A. computer program was opened and the button was tested to be certain it was functioning properly. The subject and test information were entered into the computer. Then the introductory screen was displayed, and readied to be presented to the subject.

Testing session. Upon arrival, the investigator ensured that the parent was able to find the parking area and used the parking pass. The phone in the room was then unplugged to avoid any distraction or interruption during the data collection process. Following signature of the consent and assent forms, a procedural explanation was shared with the parent and subject. The investigator confirmed the last time the child took their medication, if any that day, and confirmed the child's age.

At that point, the T.O.V.A. testing procedure was demonstrated and explained to the subject. Then, the subject took the practice test for 2.5 minutes. The results were checked to make sure the subject understood the instructions and did not have excessive anticipatory errors. If the subject was guessing, (pressing the button before the stimuli was shown) it would have shown up in the category of anticipatory errors. After reviewing the results, and reinforcing the directions to the subject, the parent was asked to sit outside the testing room. The parent was given a brief questionnaire (see Appendix B) to complete while they were waiting. The subject was then informed that they would begin the T.O.V.A. and that they could not talk to the investigator while the test was in progress.

During the T.O.V.A., the investigator observed the subject and took notes on the T.O.V.A. rating form (see Appendix C). The observed categories include visual and auditory distractibility, activity level, attentiveness or inattentiveness, general attitude, and level of mannerisms such as staring, tiring, complaining, talking, and changing the hand in which they held the button. Any comments that the subject made about the structure or the activities were also noted.

Upon completion of the testing, the principal investigator thanked the subject and their parent for participating in the study. Then arrangements for the second testing session were made.

The same procedures were followed for both sessions of the data collection process. For the second session, a condensed questionnaire was given to the parent to complete while waiting. (See Appendix D for a copy of the second questionnaire.)

Analysis

Descriptive statistics were used to describe the data and perform simple comparisons of the means. A nonparametric statistical measure was used to analyze the data for significance. A Wilcoxon matched-pairs signed-ranks test was performed on four variables of the T.O.V.A.

CHAPTER 4

RESULTS

Statistical analysis was performed on the four main variables of the Test of Variables of Attention (T.O.V.A.). The four variables included in the analysis were percent omission errors, percent commission errors, mean correct response time, and variability. Because of the difference in stimulus presentation, descriptive statistics were performed separately on half one and half two for each variable of the test in order to ascertain pattern or effect related to order of stimulus presentation. Nonparametric statistical procedures were performed on each of the variables (except variability), separately, for each half. Variability was expected to improve on both halves of the test, hence these observations were analyzed as one data set. Each subject's scores were included from both conditions, except for the two subjects whose second half scores were discarded for reliability concerns as previously mentioned.

The research hypothesis states that the subjects will perform better in condition A (small structure) than in condition B (large structure). As previously stated, mean correct response time (hereafter called response time) and variability are the critical variables for analysis and implication of ADHD. These two variables are predicted to be numerically less in the small structure compared to the large structure.

Descriptive Statistics

Comparison of means

Comparison of the means for response time revealed that there was a difference between the large and small structures, both during the first and second halves of the test. Table 2 displays the differences in response time. Results indicated approximately 5% difference in response time in the small environment, with the response time shorter in the small structure than in the large. Figure 2 graphs the means in both the large and small structures for both halves of the test.

Comparison of the measure of variability also revealed a difference between the large and small structures, again in both halves of the test. Table 3 shows the differences in variability. Results indicate approximately 15% difference, with more consistent behavior and less variation manifested in the small environment.

Table 2. Means of response time reported in milliseconds.

	1st HALF (n=14)		2nd HALF (n=12)	
	Small	*Large*	*Small*	*Large*
$\bar{X}$	490 ±75	516 ±75	469 ±78	497 ±96
		diff=26		diff=28

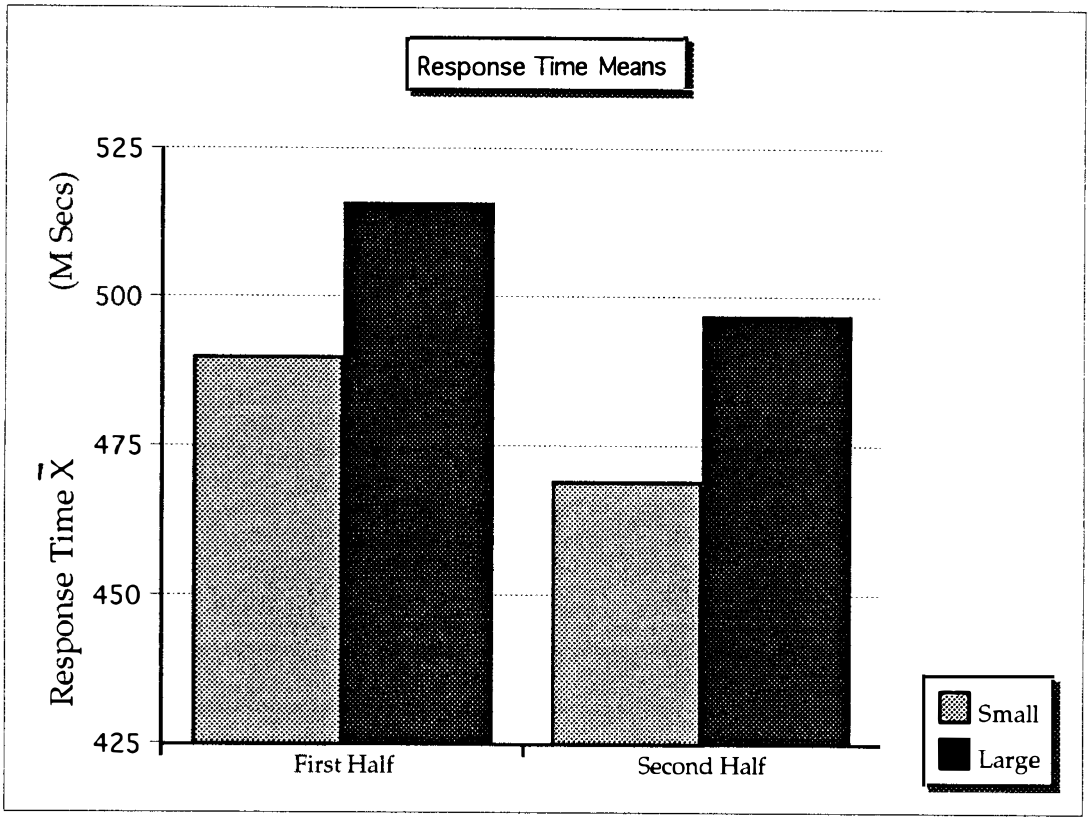

Figure 2. Graph of response time means in the large and small structures.

Table 3. Means of variability reported in milliseconds.

	1st HALF (n=14)		2nd HALF (n=12)	
	Small	*Large*	*Small*	*Large*
$\bar{X}$	129 ±49	156 ±52	156 ±28	176 ±43
		diff=27		diff=20

As the graph in Figure 3 illustrates, subjects performed more consistently in the small environment. A comparison of these means for both halves consistently revealed that the variability mean in the small structure was lower than the variability mean in the large structure.

Comparison of the difference in means for percent omission errors showed that there was not a significant difference between the large and small-sized environments. Table 4 reports the mean scores.

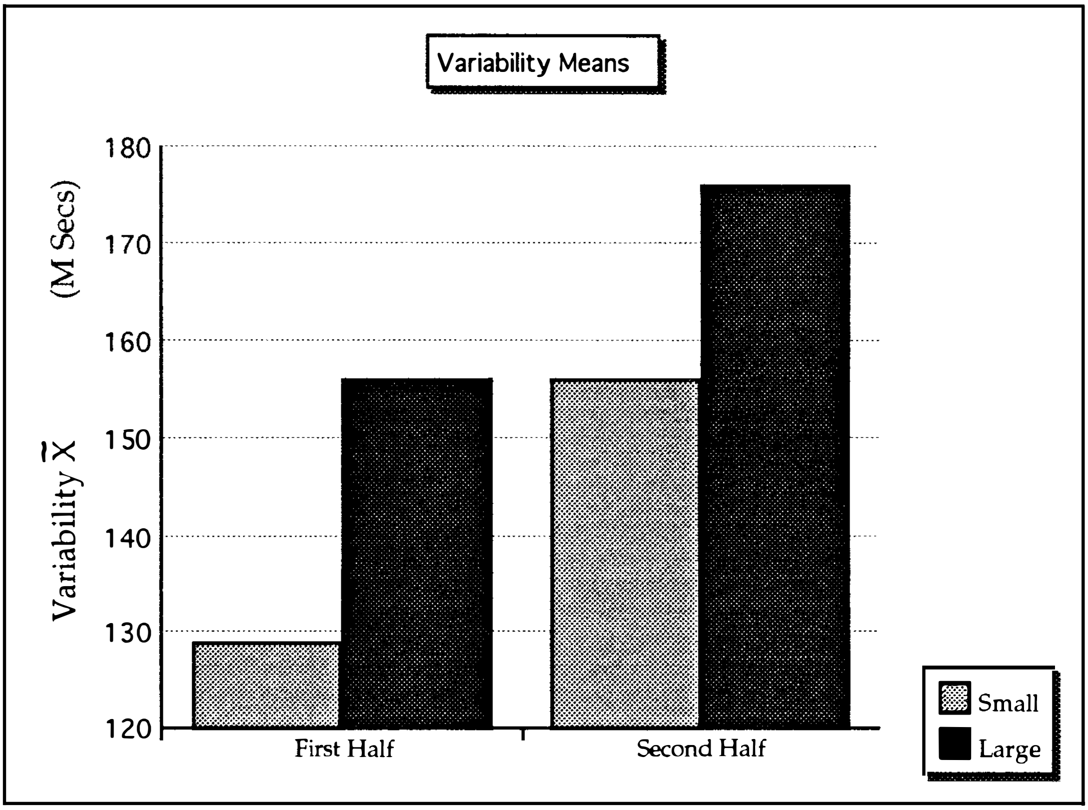

Figure 3. Graph comparing variability means in the large and small structures.

Table 4. Means of percentage of omission errors.

	1st HALF		2nd HALF	
	Small	*Large*	*Small*	*Large*
$\bar{X}$	1.401 ±1.825	.505 ±1.056	1.469 ±1.891	1.055 ±1.569
	(n=14)		(n=12)	

Comparison of the difference in means for percent commission errors revealed that there was a difference between the large and small-sized environments. In the first half of the test, scores in the small environment were greater than those in the large environment. While in the second half of the test, scores in the large environment were greater than those in the small environment. Table 5 reports the mean scores.

Table 5. Means of percentage of commission errors.

	1st HALF		2nd HALF	
	Small	*Large*	*Small*	*Large*
$\bar{X}$	.852 ±.657	.597 ±.487	16.001 ±15.762	22.77 ±23.90
	(n=14)		(n=12)	

Nonparametric Statistics

Wilcoxon matched-pairs signed-ranks test

The Wilcoxon matched-pairs signed-ranks test revealed that the difference in response time was not significant. However, the standard deviation or measure of variability for both halves of the T.O.V.A. revealed that 18 out of 26 subjects did better in the small structure than in the large structure ($Z = -2.04$, $p < .05$, one-tailed, $p = .02$).

The measures of percentage of omission errors revealed that in the first half of the test, 9 out of 14 cases were tied between the small and large environment ($Z = -2.02$, $p < .05$, 2-tailed, $p = .04$). In the second half of the test, in 8 out of 12 cases, the omission errors in the small environment were greater than those in the large environment ($Z = -1.25$, 1-tailed, $p = .10$). As seen in Table 4, the differences in these scores were not great.

The measures of percentage of commission errors were not significant but may be of interest for the trend that was observed. For the first half of the test, in the stimulus infrequent situation, 8 cases out of 14 made more commission errors in the small structure than in the large structure ($Z = -1.47$, 2-tailed, $p = .14$). During the second half of the test, in the stimulus frequent presentation, the trend reversed with 9 out of 12 cases making more errors in the large structure when compared to the small structure ($Z = -.94$, 1-tailed, $p = .17$).

CHAPTER 5

CONCLUSION

The initial research question was to test the ability of a reduced-scale environment to improve attention span in eight- to twelve-year old children with Attention Deficit-Hyperactivity Disorder. As hypothesized, subjects improved their measures of attention on the critical variables. More information was available for processing in the nervous system through the introduction of decreased spatial scale. Studies with larger groups of subjects are needed in order to generalize from these findings.

A discussion of the significance of the results follows, with explanations for those subjects who did not respond in the expected direction. Implications of this research are also presented.

Variability

On the T.O.V.A., mean correct response time is interpreted as a measure of information processing. Although the difference in response time was not significant, the standard deviation or variability of response time was significant at $p<.05$. Variability is interpreted as a measure of consistency of performance. The subjects performed more consistently in the small environment compared to the large environment. The variability measure began to show a trend that can be expected to continue with an increase in the number of subjects participating in the study.

Given that the variability measure is the crucial variable in correlating T.O.V.A. response with Attention Deficit Disorders (Greenberg, 1993b), this finding appears significant. Returning to the theory of experiential space-time relativity (De Long, 1981, 1985, 1994), the amount of information accessed was presumably greater, and processing was more consistent in the small structure.

The large structure was volumetrically 5.36 times larger than the small structure. In other words, the spatial volume in the small structure was 18% of the spatial volume in the large structure. The improvement of variability measures was approximately 15% in the small space when compared to the large space. With an 82% reduction of space, a 15% improvement in a critical variable was observed.

Errors

Percent Omission Errors

The comparison of omission errors did not reveal a significant difference. However, in both the large and small structures, the subjects' scores fall within one standard deviation of the established norms. This may be attributed to the fact that both the large and small structures were relatively smaller than most classroom environments, a bedroom or any typical living space throughout a home to which these children are accustomed. Hence, the subjects may have been processing more information on this simple measure in both the large and small structures used in this research.

Percent Commission Errors

Although not significant, an interesting trend was observed in the percentage of commission errors. During the first half of the test, more errors were made in the small environment. This was the stimulus infrequent condition, where the child must wait through several "non targets" for the appearance of the "target." If indeed the scale-reduced environment renders the nervous system more sensitive, more commission errors would be expected. In a sense, increased sensitivity might create a situation of "seeing or expecting to see things that are not present."

By contrast, during the second half of the test, the trend reversed with more commission errors in the large environment. During this half of the test, the "targets" were frequent and subjects tended to establish a rhythm of response. It then became more difficult to inhibit response when the "non target" appeared. In this scenario, with an abundance of stimuli to which subjects must respond, the sensitivity to information improved through fewer errors in the small environment.

The subjects' responses on the variables of commission errors, mean correct response time, and variability seems to reflect a heightened sensitivity and increased information processing. These results parallel those of the effect of pharmaceutical stimulants that offer an "enhanced alertness" (Snyder, 1974).

Subjects who did not improve in the small structure

Information obtained through review of the T.O.V.A. rating forms (see Appendix C), provided insight into why certain subjects did not improve in the scale-reduced condition. These forms were completed by the investigator while the subjects were taking the T.O.V.A. Scores are expected to worsen the second administration of the test, due to the boring nature of the T.O.V.A. (Greenberg, 1987). Figure 4 provides an illustrative graph of expected test results. It should be recalled that the counter balanced design was planned to control these novelty effects. After reviewing the T.O.V.A. rating forms, the investigator arrived at the explanations given in the following paragraphs.

Test/Re-test - Group One

In this study, six of the fourteen subjects were exposed to the scale-reduced structure during the first administration of the T.O.V.A. For group one, the second administration of the T.O.V.A. happened in the large structure. In the first half of the test, one subject whose scores were better in the large structure commented that the test "seemed like an hour" in the small structure. The actual elapsed time of the test was 22.5 minutes. This observation is similar to the subjective comments of subjects in De Long's study (1983) who "felt" that games played on the smaller 7" computer monitor were longer than games played on the 23" screen.

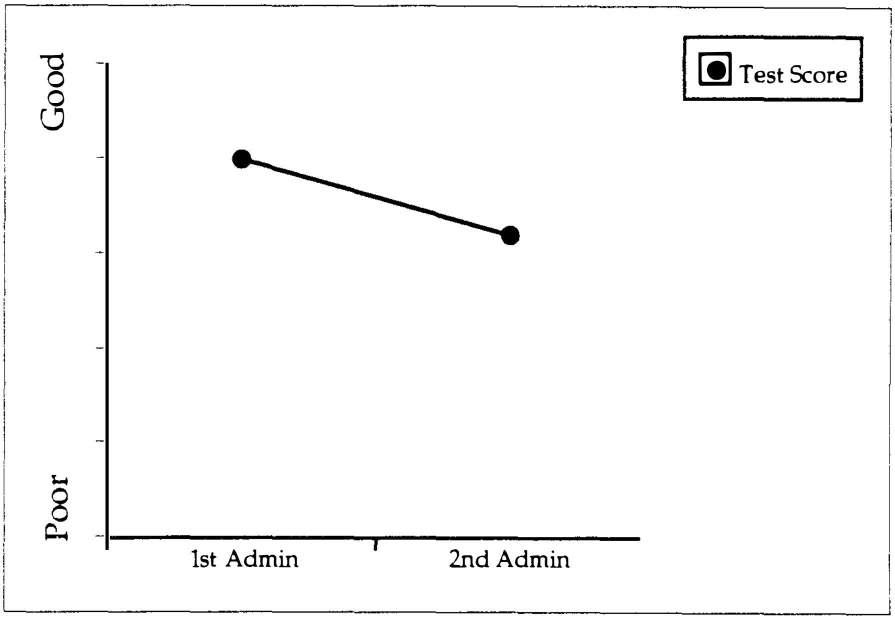

Figure 4. Graph of expected scores due to boredom. ***For illustrative purposes only.***

Another subject whose scores worsened in the small environment had pushed the chair back to the entry of the structure. Hence, he was not fully enclosed in the reduced-scale space. This subject, in both halves of the test, had better scores in the large structure.

Test/Re-test - Group Two

First half. Eight out of 14 subjects were exposed to the small structure during the second administration of the T.O.V.A. Therefore, all things being constant, all eight of them would be expected to perform poorly the second time or in the scale-reduced structure. However, during the first half of the test, the performance of only two worsened when compared to the large environment. The strength of the scale reduction was able to overcome the expected outcome.

Review of the behavioral rating forms indicated that one of the subjects whose scores worsened in the small space was tired and said he may have fallen asleep during the second administration of the T.O.V.A (which took place in the small space). During the second administration of the T.O.V.A., in the small space, another subject was highly distracted and missed seeing some of the "targets" because she looked behind her toward the investigator six times during the T.O.V.A. She also changed which hand she held the button switch several times, dropped the button switch, and commented about slight noises coming from outside the testing room. This subject performed better in the first administration of the T.O.V.A., in the large structure. The subject's actions in the small space indicated that the subject was highly distractible and may explain the poor performance during this second testing session in the small structure.

Second half. During the second half of the test, two different subjects from group two had scores that worsened in the small structure (the second administration of the T.O.V.A.). One of these subjects had pushed the chair way back from the computer monitor to the point that she was sitting at the entry into the structure. She was not fully enclosed in the small structure; hence, the full effect of the spatial reduction was not realized. This subject also had a caffeine drink two hours prior to testing in the large structure (or first administration of the T.O.V.A.). Burnstein et al. (1994) reported that caffeine can significantly improve

T.O.V.A. performance. The other subject whose performance worsened during the second half of the test (or second administration of the T.O.V.A., in the small structure) reportedly had a headache and was sleepy.

These subjects' scores could have been deleted from the data set. However, it was not evident whether these issues would have an impact on the results. It is noteworthy to include them as examples of the potentially sensitive nature of scale relationships. The usual nature of the T.O.V.A. predicts a decrease in performance the second time the test is administered (Greenberg, 1987). Six of the eight subjects who were in this group (the second administration of the T.O.V.A. happened in the small structure) increased performance, demonstrating the strength of spatial scale to overcome expected outcomes.

Implications

Several issues of current debate among clinicians, parents, and teachers of ADHD children give credence to the scale-reduced spatial intervention. One concern is the difficulty of diagnosis and belief that many children are misdiagnosed (Goodman & Poillion, 1992). A recent five-year study commissioned by the National Institute of Mental Health (Richters et al. 1995) reported a review of the literature and concluded that there was an insufficient basis for answering the question, "Under what circumstances and with what child characteristics do which treatments have what impacts on what domains of child functioning to what extent and why?" (p. 987). This manifold question emphasizes the point that despite enormous economic investment in research, there remains a lack of substantive explanations of the effectiveness of treatment options.

Advantages of Scale-Reduced Environments

Drug therapy. The most common treatment approach is drug therapy. In light of recent reports of stimulant abuse (Bogdanich & Jarriel, 1995) and severe side effects (Friend, 1995), increasing concern has risen in support of accurate diagnosis and prescription of safe and effective drugs. Given these questions and conflicts surrounding the accuracy of diagnosis and possible side effects or abuse of drug therapy, scale-reduced environments are important because they offer a benefit to all children regardless of supposed attention span and have no negative side effects.

Behavior modification. Scale-reduced environments do not require constant remediation, as is the case with behavior modification (Barkley, 1981; Lahey, 1979; Purvis, Jones & Authement, 1992). Therefore, the addition of a scale-reduced space into a classroom would free the teacher of time consuming intervention with an ADHD child.

Neurofeedback training. Unlike neurofeedback training, scale-reduced environments do not require time consuming and expensive training with professionals. (See Cartozzo, Jacobs & Gevirtz, 1995; Scheinbaum, Newton, Zecker & Rosenfeld, 1995; Lubar, Swartwood, Swartwood & O'Donnell, 1995 for a discussion of neurofeedback training.) For example, after 48 sessions of neurofeedback training, Scheinbaum, Newton, Zecker & Rosenfeld (1995) were able to demonstrate that 8-12 year old ADD children made significant gains in performance on the T.O.V.A. The scale-reduced structure does not require training sessions. In the present study, benefits were manifested the first time the child was tested in the small structure. However, caution is advised as continuous exposure and repeated exposure to a scale-reduced environment need to be tested. Repeated exposure to scale-reduced environments needs to be tested in order to determine if the effect of reduced spatial scale increases after repeated exposure.

Distraction. Hooper and Reid (1985) proposed distraction to be a factor inhibiting on-task behavior. The "distracter shield" that they used to increase attending or on-task behavior was similar to a library carrel. In other words, it was a scale-reduction of the immediate environment.

In the present study, distraction was ruled out through holding constant the placement and size of the windows in both structures. Incidentally, there were no distractions in the testing room. The investigator was the only other person in the room. Parents and siblings waited outside the testing room. The realized effect was due to the scale-change and not the amount of distractions.

However, in a previous study by De Long et al. (1994), a screened porch-like scale-reduced structure was placed in a regular day care classroom. The screen allowed for transmission of visual and auditory distractions coming from the other children and adults in the classroom. The impact of the scale reduction was still realized as evidenced by the play segment lengths. The subjects entered complex play quicker, and engaged in longer play segments in the small screened enclosure. Hence, the amount of activity that took place in the classroom did not deter from the effect of the scale-reduced environment.

Scale relationships. As one can observe from the norm charts (see Appendix E), numerical scores on the T.O.V.A. decrease as the person ages, or they improve as the person grows and matures. This could be another indication of how a person's physical size, in relation to their environment, affects the individual's information processing system. As the person gets larger, relative to their external environment, their ability to process information increases (De Long, 1994). In light of the data reviewed about the ADHD child's scholastic, social, and behavioral challenges, the scale-reduced environment becomes a simple intervention, that can be implemented while the child is young and small, without adverse side effects.

Significance of this Study

There are many questions yet unanswered about the cause of ADD with or without hyperactivity. The efficacy of the variety of treatment approaches continues as a topic of debate, as does the accuracy of current diagnostic measures. Scale-reduced environments offer improvement in information processing to all, young and old (De Long, 1981, 1983, 1985, 1994; Brickey, 1994), with or without ADD.

Gupta, Groves, Moran & Nelson (1995) recently reported that children prefer small environments when given a choice of play environments. Parents, teachers and clinicians have shared anecdotal evidence of the benefits scale-reduced environments provide to ADHD children (Barkley & Dawkins, 1992; Lubar, 1994). Yet, it has not been documented. The current study fills the gap in research and paves the way for further inquiry into the effect of spatial scale on children with Attention Deficit-Hyperactivity Disorder.

The simplicity and neutrality of a scale-reduced environment seems a natural intervention with the myriad of controversies surrounding the many facets and implications of ADD. Since there are no side effects, small environments could be used by any child in the natural environment of a classroom. If there is any feeling of claustrophobia, the child could remove themselves from the small space. The availability of a scale-reduced structure to all, could reduce the stigma that only children "with difficulty" use the small structure.

Of further significance is the ability of designers, teachers, and parents to change the temporal experience of a child through spatial intervention. The amount of information processed can be increased by simply immersing the ADHD child in a scale-reduced environment, at home and at school.

The goal of this study was to provide a simple and inexpensive alternative treatment for children with Attention Deficit-Hyperactive Disorder, allowing them to have access to more efficient learning opportunities without the use of psycho stimulants. The ramifications of this study indicate that scale-reduced structures can provide the occasion for more efficient information processing and altered attention spans.

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APPENDICES

APPENDIX A

TOVA Instructions

Suggest to children that they use the bathroom first.

- **" We will be working together for about 30 minutes and we won't be able to take a break until we're done."**

Invite parents in to see where we are testing. They can watch the practice test portion.

- **Do they wear glasses?** They don't need them to see, but glasses if are already worn, they will help reduce eye fatigue.

- TAKE OFF WATCH, give to parent to keep.

Have child sit in chair, then explain purpose of the test.

- "**We are going to measure how fast you recognize the target when it flashes on the screen. We're going to measure how fast you do that in milliseconds, thousandths of a second, that's why we use the computer. Now, here's how this works. We have two pictures that flash on the screen (show on monitor) The first picture, is the target. The target is the picture of a square with a hole on top. Press the button when you see the target."**

- **Determine which hand they write with** - have them hold the switch in that hand, so it's comfortable and not fatiguing to the hand.

Ask them to **press the button.** Explain that it's not necessary to press the button hard and hold it down. "**Just press lightly until you hear the click. Try it again. Good."**

- **"Now every time you see the target (show picture) you press the button once - only once. When you see this picture (show non**

target) don't press the button, ignore that picture. That's the whole game. Your job is to be as <u>FAST</u> and as <u>ACCURATE</u> as you can be. Press the button every time you see the target, the square with the hole on top. Don't be too fast, don't be so fast that you guess and make a lot of mistakes. It's okay to make mistakes, we all make mistakes on this test, but try not to make mistakes. "

- "**Be fast and accurate. Let's try a practice test. This doesn't count.**"

  In early part of practice test, reinforce their responses.

- When they press button after seeing target, say "**Great, that's right.**"

- When they don't press the button after seeing a non target, say "**That's it, you've got it**"

- If they press the button for the non target, say "**Gotcha, that's right, that's the one you don't press for.**"

After about 12 targets they pretty much get it. Then back up and prompts can decrease.

After practice session, ask parents to wait in waiting room. (Give them forms to fill out.) Tell them "**it's going to take about 30 minutes.**"

Look at practice test results--

<u>Anticipatory errors</u> - pressing button too soon, before they could differentiate between the two stimuli. (Messes up results.) <u>If they have anticipatory errors, give them further instructions:</u> "**Remember, don't guess, because these pictures are presented randomly, which means you can't predict which it's going to be. You need to be fast, but not too fast, because if you guess, we may have to do the test again.**"

- **"Now, we're ready to do the test. I'll press the button to start the test.**

By the way, I'll be here while you take the test, but we won't be able to talk while you're doing it, I'll be right over there. Are you ready? Remember, you push the button when you see the square with the hole on top, okay, let's begin."

Push button and retreat

In most test situations, prompts aren't needed. Some will remark how boring the test is part way through it. If you don't respond, they'll usually keep on going. If it looks like they're falling asleep, you have to prompt them. The least number of prompts the better.

In norming tests, there were no prompts. Usually more important to get test done than to have it pure and proper. Sometimes you can say, "Good, almost done."

At least, get them through first 11 1/2 minutes of the test.

APPENDIX B

Parent Questionnaire #1

1. Please list your child's regular medication schedule, include schedule during school and during summer if different. Please note which schedule they are currently on.

    School year
    Time of day
    Type of medication
    Dosage

    Summertime
    Time of day
    Type of medication
    Dosage

2. Last **time** your child took medication today?

3. Please list the last **time** your child ate a meal today.

4. Please briefly list any special circumstances your child may be experiencing today that may affect his/her performance.

5. Has your child had any caffeine drinks today?
If so, what time?

APPENDIX C

TOVA Rating Form

Distractible - Is the person visually or auditorially distractible?

Activity level - Do they become more active as the test goes on?

- What happens to them when they become bored and frustrated?

    - do they become oppositional?
    - or negativistic?
    - do they complain?
    - or do they run out of steam and wear out and shut down?
    - do they start looking around the room?
    - do you need to prompt them to keep them on task?
    - do they change hands that they are holding the button in?

APPENDIX D

Parent Questionnaire #2

1. Last **time** your child took medication today?

2. Please list the last **time** your child ate a meal today.

3. Please briefly list any special circumstances your child may be experiencing today that may affect his/her performance.

4. Has your child had any caffeine drinks today?

If so, what time?

APPENDIX E

Table 6. T.O.V.A. Clinical Norms - Variability (msec)

Years of Age		Half
	one	two
Age 8-9		
Male (n=90)	137.47±40.23	163.73±50.61
Female (n=99)	139.71±36.47	172.40±44.94
Age 10-11		
Male (n=90)	108.46±33.02	118.86±42.55
Female (n=82)	115.19±30.81	131.33±41.64
Age 11-12		
Male (n=104)	98.31±33.55	112.69±37.83
Female (n=118)	97.39±39.05	104.88±36.17

VITA

Julie K. Nelson graduated from Brigham Young University in 1987 with a Bachelor of Fine Arts degree in Interior Design. She then worked as an Interior Designer for four years in a large design firm in Southern California. There she was able to practice interior design in its many forms: retail design, residential design, model home design and hotel and restaurant design.

It was while working at Lusk Interiors in Irvine, California that she heard Tony Torrice speak about designing environments for children. From Mr. Torrice's enthusiastic presentation, Julie gained the interest and desire to specialize in designing spaces for children. A search for information on the topic began. Ms. Nelson found that research was lacking on specific aspects of the environment that support and encourage a child's development. She was able to attend two seminars dealing with the topic at the Harvard Graduate School of Design.

In 1993, at the University of Tennessee, Knoxville, she began to pursue a graduate degree in Interior Design, with a focus on children's environments. Her educational experience at UT has been rich and rewarding. Upon completion of her master's degree, Ms. Nelson plans to pursue a college teaching position as well as develop a consulting firm specializing in the design of children's environments.