

1996

Adult attentional functioning in families with children diagnosed as attention-deficit hyperactivity disorder

Michael C. McDonough
College of William & Mary - School of Education

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Adult Attentional Functioning
in
Families with Children Diagnosed as
Attention-deficit Hyperactivity Disorder

A Dissertation

Presented to

The Faculty of the School of Education
The College of William and Mary in Virginia

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

by:

Michael C. McDonough

May, 1996

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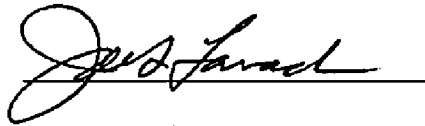
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Approved May 1996 by

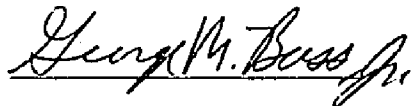


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Dedication

**“Now faith is the assurance of things hoped for, the conviction of things not seen.”
Hebrews 11:1**

This dissertation is dedicated to my wife and best friend in all of this world.

Jo-Anne Joy Walker-McDonough

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Vita

Acknowledgments

The completion of a dissertation requires the cooperation and support of several individuals. The author expresses his heartfelt thanks to all who assisted in this study.

The author wishes to thank the individuals who gave of their time to be subjects in this study. For many they gave up time with their families during weekends and evenings to graciously be research subjects.

A special thank you is extended to the to this author's advisor and committee chairman, Dr. John Lavach. His patience, guidance, and encouragement have greatly influenced the author's completion of this project and his doctoral program. Appreciation is also extended to Dr. Roger J. Ries and Dr. George M. Bass, Jr.. Their concern, assistance and support as teachers and committee members have been invaluable and greatly appreciated throughout this project.

The author's wife, Jo-Anne and children, Matthew and Kate deserve much of the credit for the successful completion of this project. They were courageous enough to move to Virginia and take part in this adventure.

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Adult Attentional Functioning in Families with Children Diagnosed as Attention-deficit Hyperactivity Disorder

ABSTRACT

The purpose of this study was to explore what differences, if any, existed between individuals and families with or without children diagnosed as Attention-deficit Hyperactivity Disorder. Information was gathered to identify subjects according to such demographic and situational variables as age, race, education, occupation, income, and performance on tasks requiring sustained attention and concentration. To further understand possible etiology each subject completed a neuropsychological battery. Collected data was analyzed to determine if the differences were significant.

The subjects were selected from the author's private practice and the local churches and schools that refer to that practice. Each subject completed a biographical questionnaire, the Gordon Diagnostic System (GDS) and the Luria-Nebraska Neuropsychological Battery, Form I, Adult version (LNNB). Chi-square analysis, t-tests, and difference of proportions tests were used to examine the collected data.

The groups were similar in terms of age. There were no statistically significant differences between groups on the LNNB. Several of the differences on the GDS measures of vigilance and distractibility did not achieve statistical significance.

Significant differences were noted on variables including education levels, response times during measures of sustained attention, concentration and distractibility, and historical behavioral checklists. A trend analysis of the findings was offered suggesting visual processing as contributing to the delays in response time. The performance of individuals demonstrating problems with attention, concentration, and distractibility revealed significant problems with writing and mathematics. Implications, conclusions, and suggestions for further research were offered.

MICHAEL C. McDONOUGH

SCHOOL OF EDUCATION

THE COLLEGE OF WILLIAM AND MARY IN VIRGINIA

Adult Attentional Functioning
in
Families with Children Diagnosed as
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Chapter 1

Introduction

Statement of the Problem

Biederman, Newcorn and Sprich (1991) report that Attention-deficit Hyperactivity Disorder (ADHA) is one of the most common sources of referrals to family physicians, pediatricians, pediatric neurologists, and child psychiatrists. Its impact on society is significant in terms of financial cost, stress to families, disruption in schools, and the potential for leading to criminality and substance abuse. According to Barkley (1993) individuals with ADHD display poor organization and planning, a distorted sense of time management, deficits in mental arithmetic computation, delayed self directed speech, immature social communications with peers, heightened emotionality and diminished problem-solving ability. Gordon, McClure and Post (1986) describe ADHD as one of the more perplexing and controversial issues in mental health. Some of this confusion has resulted from attempts to describe hyperactivity. Hyperactivity has, in the past, referred to an individual's overall level of motor output (American Psychiatric Association, 1968; Stewart, Pitts, Craig, & Dieruf, 1966), the presence of neurological damage or minimal brain dysfunction (Clements & Peters, 1962; Strauss & Lehtinen, 1947), autonomic dysfunction including arousal or autonomic responsivity, or a disorder of higher cognitive

structures including those involved in metacognitive strategies for problem solving (Gordon, McClure, and Post 1986; Teeter, 1991). Kohn (1989) and Hales & Hales (1996), writing in nonmedical, general interest magazines, indicated one of the most important findings relevant to hyperactivity within the last decade was that it does not usually disappear at puberty and currently at least 5 million adults within our country are afflicted.

Denckla (1991) reports that children diagnosed with ADHD come from families where parents, particularly fathers, report similar symptoms. Zimetkin (Zametkin, et al., 1990) expanded the clinical reports of parents by combining assessments of sustained attention or vigilance (continuous performance tasks) and physiological brain imaging (positron emission tomography). Their research indicated that extensive frontal and parietal areas of the right hemisphere show reduced metabolic activation during sustained attention/continuous performance testing in parents of ADHD children.

Barkley (1990) reports 40 to 50 % of child referrals to mental health clinics are for attention related problems. The frequent moves, job changes, and community problems of adults in such families are often overlooked. This study addresses some of these concerns by evaluating the parents of children with attention related problems and comparing their clinic performance on objective measures, behavior checklists and demographic data with a control group who have children with no known attention problems.

The Diagnostic and Statistical manual of Mental Disorders, 3rd ed., revised (DSM III-R) has recognized long standing adult hyperactivity with the addition of the ADHD - residual type (ADHD-RT). The DSM III-R further notes "among family members, the following disorders are thought to be overrepresented: Alcohol Dependence or Abuse, Conduct Disorder, and Antisocial Personality Disorder" (p.51). The Diagnostic and Statistical manual of Mental Disorders, 4th ed. (DSM-IV) reported the prevalence of ADHD at 3-5 % in school-age children and that data on prevalence in adolescence and adulthood are limited (p.82). Research by Cantwell (1972, 1975a) and Morrison & Stewart (1973b) describe adults in families with ADHD children as having elevated incidents of sociopathy and Briquet's syndrome (hysteria). This study addresses the following research questions aimed at examining genetic factors in ADHD:

(1) How does the performance of parents who have children diagnosed as Attention-deficit Hyperactivity Disorder differ from that of similar adults with no family history of ADHD on performance based measures (The Gordon Diagnostic System) and on demographic and historical behavioral data?

(2) What identifiable neuropsychological deficits exist for parents with ADHD children as measured by the Luria-Nebraska Neuropsychological Battery (LNNB)?

Justification for the Study

Although Zametkin (Zametkin et al., 1990) describes Attention-deficit Hyperactivity Disorder (ADHD) as a disorder of unknown cause. Voeller (1991) maintains ADHD is a relatively common disorder interfering with an individual's ability to function in school and, later in adulthood, and according to Gordon (1986), ADHD has rapidly become one of the most diagnosed disorders in the United States. ADHD is a chronic illness, the manifestations of which change as the individual matures (Voeller, 1991). The Diagnostic and Statistical Manual of Mental Disorders, third edition - Revised (DSM III-R) notes "this disorder is common, occurring in as many as three percent of school age children and is believed to be more common in first-degree biological relatives (brothers, sisters, children) of people with this disorder than in the general population." (p.51). The DSM-IV indicates that ADHD has been found to be more common in the first-degree biological relatives of children with the disorder and it is not yet entirely clear what fundamental cognitive deficit is responsible for the difficulties encountered by these individuals during tests that require effortful mental processing (pgs. 81 & 82). Research by Gordon, McClure and Post (1986) indicate ADHD might be present in five to ten percent of the school age population. Barkley's estimate of the incidence of ADHD is somewhat more conservative (3-5%); however, 30 to 40 % of the referrals to child guidance clinics result from concerns regarding attention and concentration (LaGreca & Quay, 1984, Lorys, Hynd, & Lahey, 1990 p.120).

Studies suggest that ADHD symptoms persist into adolescence and adulthood in 40 to 60 percent of people with childhood hyperactivity (Feldman, Denhoff, & Denhoff, 1979; Gaultieri, 1995; Hechtman, Weiss, Finkelstein, Wener, & Benn, 1981; Hechtman, Weiss, Perlman, & Amsel, 1984; Kohn, 1989; Menkes, Row, & Menkes, 1967; Milman, 1979; Morrison, 1974, 1980; Weiss, Hechtman, Perlman, Hopkins, et al., 1979). The level of social development and interpersonal skills is lower for most ADHD adults than for their age controls (Morrison, 1980; Paternite, Loney, & Langhorn, 1976). Studies by Amado & Lustaman, 1982; Carlson & Cantwell, 1980; Eyre, Rousaville, & Kleber, 1982; Gaultieri, 1995; Wood, Weder, & Riemherr, 1983; suggest ADHD is a precursor of adult psychopathology. Family and adoption studies (Cantwell, 1975 a,b; Morrison & Stewart, 1973b) and studies comparing biological relatives and adoptive relatives (Deutsch, Swanson, Cantwell, & Baren, 1980; Deutsch, Swanson, & Bruell, 1982) have supported a genetic hypotheses for ADHD. The above studies state the need for further investigation of a genetic mechanism for ADHD.

A study by Cantwell (1975a) provided evidence for the hypothesis of genetic transmissions of ADHD symptoms. In 1975 children with ADHD symptoms were diagnosed with the hyperactive child syndrome (HACS). HACS was found at significantly higher levels ($p < .025$) in biologic first and second degree relatives of hyperactive children than in adopted relatives. The prevalence rates for HACS found in adopted relatives was no greater than that found for the relatives in the control groups. The diagnosis of HACS in Cantwell's study was made using a systematic and structured

interview. No performance-based measures were used. Cantwell recommended further investigation since the interviewer was familiar with the identity of parents in the biological, adopted, and control groups. This study made use of objective, performance-based measures which addressed the issue of possible interviewer bias.

Twin studies have also shown greater incidence of inattention and overactivity between monozygotic (MZ) twins than between dizygotic (DZ) twins (O'Conner, Foch, Sherry, & Plomin, 1980; Willerman, 1973), further suggesting some role for genetics in the transmission of these characteristics within families. The results of a study by Lopez (1965) indicated complete concordance for hyperactivity among monozygotic twins, but only a 17% concordance rate among dizygotic twins. Studies by Cunningham & Barkley (1978) and Heffron, Martin, & Welsh (1984) reported similar findings. A study by Goodman & Stevenson (1989) evaluated the heritability of hyperactivity among 127 MZ and 111 DZ twins. Concordance for clinically diagnosed hyperactivity was 51% among the monozygotic twins and 33% among the dizygotic pairs. Common environmental factors accounted for between 1 and 30% of the variance in ADHD symptoms in the Goodman & Stevenson study. Recently a twin study using regression analysis has further supported that attention and hyperactive symptoms appear to be highly hereditary (Gillis, Gilger, Pennington, & DeFries, 1992). The authors of the above studies indicated such data argue against any theory attributing hyperactivity entirely to environmental factors such as poverty, overcrowding, chaotic family style, pollution, or food additives.

The DSM III-R lists the diagnostic criteria for Attention-deficit Hyperactivity Disorder as a disturbance of at least six months during which at least eight of the following are present:

- (1) often fidgets with hands or feet or squirms in seat (in adolescents, may be limited to subjective feelings of restlessness)
- (2) has difficulty remaining seated when requested to do so
- (3) is easily distracted by extraneous stimuli
- (4) has difficulty awaiting turn in group situation
- (5) often blurts out answers to questions before they have been completed
- (6) has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension) e.g., fails to finish chores
- (7) has difficulty sustaining attention in tasks or play activities
- (8) often shifts from one uncompleted activity to another
- (9) has difficulty playing quietly
- (10) often talks excessively
- (11) often interrupts or intrudes on others. (e.g., butts into other children's games)
- (12) often does not seem to listen to what is being said to him or her
- (13) often loses thing necessary for tasks or activities at school or at home (e.g., toys, pencils, books, assignments)
- (14) often engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill-seeking), e.g., runs into street without looking

When investigating these statements it is important to consider a criteria met only if the behavior is considerably more frequent than that of most people of the same mental age (DSM III-R p. 52-53).

The DSM-IV builds on the mental age concept of the DSM III-R noting that ADHD is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development. These symptoms must have been present before the age of 7 years, although many individual are diagnosed after these symptoms have been present for a number of years. These symptoms must be present in at least two settings (e.g., at home and at school or work). The DSM-IV notes there must be clear evidence of interference with developmentally appropriate social, academic, or occupational functioning and the disturbance does not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other psychotic disorder and is not better accounted for by another mental disorder (pg.78).

Standards of practice in the assessment of ADHD recommend a comprehensive approach, involving multiple methods, informants, and disciplines (AACAP, 1991; Barkley, 1990; Cantwell & Baker, 1987; Guevremont et al., 1990; Schaughency & Rothlind, 1991). In each of the above standards, interviews, behavior rating scales, and objective measures are recommended as part of a comprehensive assessment battery. This study made use of interview techniques, rating scales and objective measures in the assessment process.

Associated features of ADHD include low self-esteem (Weiss, Hechtman, & Perlman, 1978), conduct problems (Hinshaw, 1987), and academic underachievement (Saravia-Cornelius, 1994). Additionally, negative interactions with parents (Barkley, 1989), peers

(Johnson, Pelham, & Murphy, 1985), and teachers (Whalen, Henker, & Dotemoto, 1980) are major complications of this disorder (DSM-III-R p. 51).

Gordon (1986) notes, "there has been a growing dissatisfaction with formulating a diagnosis of ADHD based almost entirely upon the perception of others or clinical judgment". Edwards, Schultz, & Long (1995) describe two problems associated with the identification and assessment of ADHD. First, they state there is no accepted single objective measure of ADHD and second, the behaviors associated with ADHD are common. Alternatives to interviews, checklists, etc. have included administering related measures of self-control (Davenport, 1972; Doyle, Anderson, & Holcomb, 1976; Hiscock, Kinsbourne, Caplin, & Swanson, 1979; Margolis, 1972) or Continuous Performance Test activities (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). Lorber (Lorber, Trommer, & Hoepfner, 1989) cited the need to include a continuous performance measure, such as the Gordon Diagnostic System (GDS), as part of a comprehensive multidisciplinary assessment of children with suspected attentional disorders. Irwin & Mettelman (1989 p. 284) note the inclusion of a behavior-based measure allows the clinician to observe the subject's functioning under conditions requiring attention and self-control.

Studies exist indicating first-degree relatives of clinically referred children with ADHD have a significantly higher risk for ADHD than relatives of normal children (Biederman & Faraone, 1990; Faraone, Biederman, Keenan, & Tsuang, 1991) however, these studies did not include a performance-based measure in the identification of their ADHD populations.

Frick and Lahey (1991 p. 168) indicated studies did not address whether existing familial association of ADHD symptoms are genetic or psychosocial in origin. Most of the above studies cited the need for future family studies aimed at understanding the etiology of ADHD. Therefore, this study compared groups of individuals with and without a first degree biological relatives previously diagnosed as ADHD and included a continuous performance task, the Gordon Diagnostic System. To address the etiology question the Luria-Nebraska Neuropsychological Battery (LNNB) was also administered.

The findings of a study by Zametkin (Zametkin et al., 1990) were supportive of previous research by Mattes (1980) and Evans (Evans, Gualtieri, & Hicks, 1986) implicating the frontal lobes as contributing to the processes of hyperactivity. Significant differences were reported in cerebral glucose metabolism between hyperactive adults and normal adults in frontal lobe regions of the brain important in the control of preparation for motor activity, motor activity itself, inhibition of inappropriate responses, and attention (p. 1366). Mesulam (1986) reported disorders of the prefrontal regions of the brain resulted in inattentiveness, distractibility, and an inability to inhibit inappropriate responses. While these studies identified specific areas of the brain as contributing to behaviors associated with hyperactivity they did not incorporate the parents of children identified with ADHD as subjects. Therefore, this study examined the first degree relatives of individuals diagnosed as ADHD and included a measure whose primary purpose is to diagnose general and specific cognitive deficits, including the lateralization and localization of focal brain impairments, the Luria-Nebraska Neuropsychological Battery (LNNB).

This study examined adults with a family member diagnosed as ADHD and a sample of adults with no family history of the disorder on a continuous performance task. Previous definitions of hyperactivity included the presence of neurological damage, minimal brain dysfunction, or disorders of higher cognitive structures (Gordon, McClure, & Post, 1986). Therefore, the Luria-Nebraska Neuropsychological Battery (LNNB) was administered to each subject. The primary purpose of the LNNB is to diagnose general and specific cognitive deficits, including lateralization and localization of brain impairments (Golden, Purisch, & Hammeke, 1988). t-tests were calculated between and within groups on the Gordon Diagnostic System, a performance-based measure of attention and concentration, and the Luria-Nebraska Neurological Battery-Adult Version, Form 1. Considering historical information is necessary in forming this diagnosis t-tests were used to compare the control and experimental groups on various behavioral variables.

Theoretical Rationale

Wilkening and Golden (1987) describe two traditional approaches to neurological explanations of human behavior: localization theory and equipotential theory. They maintained that the localization theory “posits that the cerebral cortex is a highly differentiated structure with complex mental functions localized to specific centers of the brain”. The equipotential theory suggests that for all human behavior all areas of the brain participate on an equal basis. Luria’s theory is described as a third approach that accounts for some of the discrepancies between theory and observations in the localization and equipotential models (p. 24).

Luria (1966) theorizes that human behavior is active and determined not only by past experience but also by plans and designs for formulating the future. The human brain creates future plans and designs and subordinates behavior to accommodate them. His theory is based on the study of local brain lesions which assist in the understanding of brain organization. His theory included three broad basic concepts which he defines as “function” or “functional system;”, “localization”, and “symptom” or “loss of function”. Plaisted, Gustavson, Wilkening, and Golden (1983 p. 14) further considered pluripotentiality and the lack of uniqueness of functional systems as important concepts in Luria’s theory. Pluripotentiality is the concept that any specific area of the brain can participate in several functional systems. This concept differs from standard localization concepts in that various areas of the brain cannot operate in isolation. Luria described most behavior as a function of the intercooperation of numerous areas of the brain and theorized that several areas of the brain are necessary to produce any specific behavior. Luria’s functional systems are defined as the pattern of interacting areas of the brain that must be coordinated in order to produce any given operant behavior.

The third concept of Luria’s theory considered important was described by Plaisted, Gustavson, Wilkening, & Golden (1983) as the lack of uniqueness of functional systems. Multiple functional systems may be responsible for a given behavior; therefore, injury to a particular functional system may not effect that particular behavior due to the availability of alternative functional systems. Golden (1981b) proposes that the number of functional

systems available to a person may be a “rough index of intelligence and of frontal lobe functioning”.

Luria proposed a general theory of cortical functioning which recognized the anterior cortex as more involved in motor functions with the posterior cortex more involved in sensory functions. Luria's theory divided the cortex into three areas:

1. Primary sensory and motor areas;
2. Secondary sensory and motor areas;
3. Tertiary, or association, areas.

Definition of Terms

The following definition of terms should be of benefit in clarifying some of the major constructs of this study. Unless indicated all definitions were taken from Fundamentals of Human Neuropsychology by Bryan Kolb and Ian Whishaw (1996). Definitions for anatomical terms may be found in Taber's Cyclopedic Medical Dictionary edited by Clayton L. Thomas (1993).

Attention: Seidel & Jaschko (1991) note attention is a broad concept that is difficult to define. They describe three interrelated components of attention including: (1) alertness or basic waking state; (2) selective attention; and (3) vigilance or voluntary attention. The

Gordon Diagnostic System (GDS) will examine selective attention (Distractibility Task) and vigilance (Vigilance Task).

Broca's aphasia: An expressive or nonfluent aphasia; chiefly a deficit of speech; results from a lesion to Broca's area.

Brodmann's map: A map of the cerebral cortex devised by Brodmann; it is based on cytoarchitectonic structure and labels anatomical areas by number, Kolb and Whishaw note the numbers themselves have no intrinsic meaning. (Conforms closely to functional areas based on lesion and recording studies.)

Cognitive mapping: The ability to make mental maps of one's environment and then navigate through that environment using information from the maps. These maps are not formed by some rote trial-by-trial learning process. They appear to be formed by specific cognitive processes that are the property of intrinsic neural connections.

Equipotentiality hypothesis: The hypothesis that each part of a given area of the brain is able to encode or produce the behavior normally controlled by the entire area.

Functional system: Represents the pattern of cooperation among different areas of the brain which result in a given behavior such as speaking or reading. All behavior is the

result of one functional system and much human behavior may be the result of several systems (Golden and Anderson, 1979 p. 39).

Localization of function: Hypothetically, the control of each kind of behavior by a different specific brain area.

Wernicke's area: The posterior portion of the superior temporal gyrus, roughly equivalent to area 22. Damage to this area results in Wernicke's aphasia which is different from Broca's aphasia in four ways.

1. There is damage in the first temporal gyrus, in Wernicke's area.
2. There was no contralateral hemiplegia or paralysis.
3. The patients could speak fluently, but what they said was confused and made little sense-hence the term paraphasia.
4. Although the patients could hear, they could not understand or repeat what was said to them.

Research Hypotheses

The following research hypotheses were evaluated in this study.

Hypothesis One: The performance of biological parents of individuals with Attention-deficit Hyperactivity Disorder will be significantly more impaired than the performance of controls on measures of attention and concentration.

Hypothesis Two: The performance of biological parents of individuals with Attention-deficit Hyperactivity Disorder will be significantly more impaired than the performance of controls on measures of freedom from distractibility.

Hypothesis Three: The biological parents of individuals with Attention-deficit Hyperactivity Disorder who achieve borderline or abnormal scores on measures of attention, concentration and distractibility will demonstrate significant elevations on the Luria-Nebraska Neurological Battery (LNNB) protocols.

Sample description and general data gathering procedures.

The target population for this study was the parents of children who have a diagnosis of Attention-deficit Hyperactivity Disorder. The accessible population for this study were the families with members diagnosed as Attention-deficit Hyperactivity Disorder who frequented private mental health facilities in Southeastern Virginia.

This study employed two groups with a total participation of 94 subjects. Each group consisted of adults randomly selected from the cities of Southside Hampton Roads and the Peninsula area. The experimental group (N=44) was composed of adult subjects who have a child with a diagnosis of ADHD. The control group subjects (N=50) were adults with children but no known family history of ADHD. Other restrictions for all participants in the study included no history of mental retardation or obvious physical impairments which might preclude performance on investigation instruments. The data was collected by the author through the administration of the Gordon Diagnostic System (GDS) and the Luria-Nebraska Neuropsychological Battery (LNNB), Form I, Adult version. Data concerning the parents of each research subject, the current status of each subject, including historical behavioral descriptors, and information about the children of each subject was collected by the completion of a structured interview (see Appendix 1).

Limitations of the Study

The limitations of this study are as follows:

1. There will be limits to the amount of generalization of the findings of this study due to sampling limitations.
2. The reliability and validity of the instruments employed in data gathering.
3. Lower socio-economic-economic status individuals may not be part of this study at levels found within the general population and may limit the generalization of results to those groups.
4. Some of the data collected in this study was historical and subjective and therefore limited by the accuracy and interpretation of those providing the information.

Chapter 2

Review of the Literature

Historical Developments

The earliest theories of brain-behavior relationships were those of Alcmaeon (500 B.C.) and Empedocles (490-430 B.C.). Alcmaeon believed mental processes were located in the brain. Empedocles located them in the heart. Plato (420-347 B.C.) developed the concept of a tripartite soul and placed the rational part in the brain because it was located closest to heaven. Aristotle (348-322 B.C.) decided the heart was the seat of mental processes and the function of the brain was to cool the blood. Physicians, including Hippocrates (430-379 B.C.) and Galen (A.D. 129-199), argued that the brain controls behavior citing that nerves from the sense organs go to the brain, not the heart. Galen developed his views by observing the behavior of brain injured gladiators. He believed the mind was located in the fluid of the ventricles rather than in the matter of the brain. Modern thinking about brain-behavior relationships began with the 17th century philosopher Descartes who postulated mental processes resided precisely within brain tissue (Kolb & Whishaw, 1996).

Brain Behavior Relationship Theories

Observations that the brain controls behavior led to the development of theories concerning how the brain controls behavior. Wilkening and Golden (1987 p. 24) note two traditional approaches to such theory development: localization theory and equipotential theory. Localization theory proposes the cerebral cortex is a highly differentiated structure

with complex mental functions localized to specific brain centers. The equipotential conceptualization of neuropsychology suggests that for all human behavior all areas of the brain participate on an equal basis. Luria contributed a third and different theory of neuropsychological functioning which accounts for the consistencies between both localization and equipotential theories while examining the discrepancies between theory and observation that are problematic in the other models (p. 24).

Luria (1973) attributed to John Hughlings-Jackson the first accurate assimilation of the equipotential and localizationist positions. Hughlings-Jackson viewed mental abilities as composed of a number of small, basic skills which were put together to yield a mental ability. He further proposed that the loss of any certain ability may be caused by the loss of many different abilities. Hughlings-Jackson's theory leads to two predictions. First, injuries in a specific area of the brain will cause a specific deficit. Secondly, injuries in many different areas of the brain may cause the loss of a certain ability.

Hughlings-Jackson's theory also purports that the same behavior is represented in different ways within the nervous system, a concept Luria incorporates in his functional systems. For Luria, a functional system represents that pattern of cooperation among different areas of the brain which result in a given behavior. Luria conceptualized the functional system as a chain, and if any link is broken the chain is rendered ineffective. Luria also notes if a second functional system is available the individual may show no deficit. Golden (1981 b) notes the number of functional systems available is a "rough

index of intelligence and frontal lobe functioning". Golden, Ariel, McKay, Wilkening, Wolf, & MacInnes (1982 p. 291) note of all Luria's basic theoretical notions, functional systems may be the most important (p. 291).

Luria's Three Units

Luria (1966, 1973 p. 43) has identified three major units of the brain whose intercooperation is necessary in nearly every functional system. He describes them as "a unit for regulating tone or waking, a unit for obtaining, processing and storing information from the outside world, and a unit for programming, regulating, and verifying mental activity". Luria (1973, p. 43 & 74) notes units II and III are arranged in a hierarchical structure and contain cortical zones constructed one upon the other including: primary (projection) area which receives impulses from or sends impulses to the periphery; secondary (projection-association) areas where information or programs are prepared, and finally, tertiary (zones of overlapping) areas which are responsible for the most complex forms of mental activity. He also observed the relationships between these zones changed as a child developed.

The first unit is located in the brain stem and limbic system and is involved in selective attention and arousal. It alerts various parts of the brain that there are stimuli which must be attended to and raises the arousal level of those areas to receive the stimuli. One of the most important components of this first functional unit is the reticular activating formation which Luria describes as a vertically arranged functional system (Luria, 1973 p. 46z). This formation has the structure of a "non-specific" nerve net, which performs its function of

modifying the state of brain activity, gradually step by step, without having a direct relationship to the reception and processing of external information or to the formation of complex goal-directed intentions, plans, and programs of behavior (Luria, 1973 p. 67).

The neurodynamics of Luria's first unit include the ongoing, flexible process of selective attention to relevant stimuli and inhibition of responses to irrelevant stimuli. With optimal levels of arousal this unit's functioning follows the "law of strength". The "law of strength" prioritizes stimuli in proportion to their potential biological and psychological significance.

Damage of or dysfunction in unit one results in decreased arousal and difficulties with selective attention. Purisch (Purisch & Sbordone, 1986) listed the following symptoms as commonplace with damage to or dysfunction in Luria's first unit:

1. **Disorientation:** Particularly for specific information. For example, an individual might know what city he lives in but forget his address or phone number.
2. **Adynamia:** Slowness, fatigability, sluggishness, lack of initiative, or indifference.
3. **Poor mental control and concentration:** This might include distractibility and tangential thinking.
4. **Impaired memory:** This may be due to a person's being susceptible to interference. This may not be related to a particular modality (i.e. visual or auditory) but may show lateralization effects for verbal or nonverbal material.

5. Impaired affect: They may have difficulty modulating arousal and become overwhelmed with “catastrophic reactions”. Goldstein (1939) described catastrophic reactions as lesions of the left hemisphere characterized by fearfulness and depression. Gainotti (1972) reported catastrophic reactions were associated with aphasia.

The second unit, located in the posterior half of the cerebral hemispheres, included areas of the temporal, parietal, and occipital lobes. Subcortical structures in the medial temporal lobe such as the hippocampus and amygdala are functionally important for this unit. The hippocampus is essential for normal memory while the left and right hippocampi appear to have different functions. The left is involved in the memory of verbal material, the right in the memory of visual and spatial material (Kolb and Whishaw, 1996). Damage to or dysfunction of the amygdala and the hippocampus result in the appearance of amnesia symptoms.

The second unit is responsible for the reception, analysis, and storage of information. This unit does not operate using the “law of strength” but obeys an “all or nothing” rule by receiving discrete nerve impulses and relaying them to other groups of neurons.

The primary zones of this unit include the primary visual cortex (Brodmann’s area 17), the primary auditory cortex (Brodmann’s area 41) , and the primary somesthetic (parietal lobe) cortex (Brodmann’s area 1, 2, 3, and 43). The cells contained in these areas are highly specific. For example, certain neurons within the primary visual cortex respond only

to the narrowly specialized properties of visual stimuli such as shades of color, the character of lines, or the direction of movement.

Bilateral damage to or dysfunction in the primary visual cortex results in cortical blindness (complete loss of vision). Incomplete unilateral lesions of this area result in blindspots (scotomas) often compensated for by visual scanning and nystagmus. Bilateral damage to the primary auditory cortex is characterized by cortical deafness (complete lack of hearing). Unilateral damage results in a raised threshold (often subtle) for hearing. There may be the loss of the ability to localize sounds in space. Damage to the primary somesthetic cortex results in cortical "sensory" loss for the contralateral side of the body. Damage to area 43 produces uncertain effects. Such individuals may be unreactive or have a reduced reaction to pain stimuli.

The secondary zones of unit two elaborate upon the data arriving from the primary zones. These zones impose a greater degree of organization and meaning upon the sensory information they receive. This greater meaning is derived from learning and experience. Within the secondary zones of unit two there emerges a degree of functional asymmetry between the hemispheres. For example, damage to the left hemisphere of the temporal lobe results in Wernicke's aphasia where there is a faulty analysis and synthesis of the sounds of speech, either spoken or thought. Such difficulties result in problems with reading comprehension, word finding, repetition, reading and spelling. Damage to the right

hemisphere of the temporal lobe reveals itself in the faulty perception of complex nonverbal acoustic stimuli such as music and intonations of speech.

The tertiary zones of the second unit are located in most of the regions not occupied by the primary and secondary zones, on the areas of overlap of these zones: areas 7, 39, and 40 (superior and inferior parietal), 21 and 22 (inferior temporal), and 37 (temporal-occipital). These zones process and combine information arriving from each of the individual modalities. This makes the following two major and necessary higher cortical abilities possible:

1. **Cross-modality matching:** This is the ability to match information arriving from each of the individual receptors about the same object. For example, cross modality matching occurs when an individual visually identifies a picture of an object placed into his hand (tactile-visual integration).
2. **Relational thinking:** Integration of information makes it possible to comprehend the logical relationship among individual pieces of information by providing a meaningful context in which all information is combined.

At the tertiary level, each hemisphere is specialized in the type of integration performed and the type of information processed. The left hemisphere integrates and relates information related to verbal or symbolic systems. The right hemisphere deals with integrating information on a visual-spatial, nonverbal and literal level. Rather than the dichotomy described in the split-brain literature, Purisch (Purisch & Sbordone, 1986) notes each hemisphere offers its own contribution in the processing and performing of the same task. For example, during construction tasks the left hemisphere is more adept at the

analysis of the individual components, while the right hemisphere provides for a perceptual synthesis of the overall design. He notes damage to either area will lead to different qualitative errors in such tasks.

Damage to or dysfunction in the left hemisphere tertiary zones of unit two may result in particular language impairments involving the spatial or grammatical aspects of language. Individuals with damage to these areas may have difficulty carrying out sequential actions. Injury to the left tertiary areas may result in graphesthesia and astereognosis. If the damage to these areas is deep enough to sever connections to the hippocampus and amygdala difficulties with learning new verbal material, specifically the transfer of information from short-term to long-term memory both visual and auditory, is likely.

Damage to the right hemisphere tertiary areas may result in visual agnosia. Individuals with severe damage to these areas may deny that any difficulty exists supporting the view that the right hemisphere is dominant for emotional processing. Contralateral neglect is a symptom of right hemisphere damage. This problem involves the lack of attention to stimuli presented to the left side in the absence of sensory loss. Luria described the right hemisphere as important in the mediation of background and contextual information. He observed deficits in selective attention to critical features in the environment following damage to the tertiary areas of the right hemisphere as suggesting these areas monitor and bring important information to the attention of the left hemisphere for processing. Luria noted damage to these areas resulted in deficits in incidental memory and linguistic processing involved in reading, writing and spelling.

Unit three is located in the anterior cerebral cortex and includes all of the cortex anterior to the central sulcus (the frontal lobe). This unit is concerned with the most active components of behavior and thinking; Purisch (Purisch & Sobordone, 1986) divides its functions into three interrelated tasks:

- 1. Formation of intentions and plans of behavior.**
- 2. Execution and regulation of behavior.**
- 3. Evaluation and modification of ongoing behavior in accordance with intentions and feedback received from the receptors of the second unit.**

Luria (1973 pp. 79-80) describes the function of unit three as follows: "Man not only reacts passively to incoming information, but creates intentions, forms plans and programs of his actions, inspects their performance, and regulates his behavior so that it conforms to these plans and programs; finally, he verifies his conscious activity, comparing the effects of his actions with the original intentions and correcting any mistakes he has made." (pp. 79-80). Unit three is concerned only with processing motor behavior. In this unit impulses run from the tertiary to the secondary and then to the primary zones.

The tertiary zone of unit three is divided into the anterior dorsolateral area (Brodmann areas 9, 10, 11, 45, and 46); and the orbital area (Brodmann areas 11, 12, 34, and 47). This is the area where activities are planned and intentions formulated. These ideas are then transmitted to the secondary and primary zones for execution. The tertiary zones of unit three are also involved in the evaluation and modification of behavior. These zones have reciprocal connections with all other parts of the brain which not only makes it possible for these zones to receive information from other areas but also to influence the

actions of those areas. The connections these zones have with unit one can elicit more arousal when it is required for concentration, thinking and activity. These connections can also reduce arousal when the organism must calm down or demonstrate inhibition.

Dysfunction of the tertiary areas of unit three results in the following symptomology:

1. Slowness, decreased spontaneity or initiative, lowered rate of behavior, apathy, unresponsiveness, etc.
2. Cognitive inflexibility and behavioral preservation, or the opposite, distractibility.
3. Deficient self awareness and lack of critical attitude. May be inappropriately euphoric, lack anxiety, impulsive, and behave in a socially inappropriate manner.
4. Concrete attitude typified by egocentrism, lack of foresight or planning, and inability to sustain goal-directed behavior.

The secondary zones of unit three integrate individual movements into functional units. They process individual bits of data into meaningful units on the basis of learning and experience. These units are described as containing "functional packages" of prepared movements which are conveyed to the primary zones for execution.

Dysfunction of the secondary zones of unit three results in an impairment of the ability to make smooth transitions between the separate, discrete movements. The drawing, speaking, or writing of individuals with damage to these zones is frequently impaired. Damage in these zones results in telegraphic speech. Luria contends these zones are critical in the workings of "internal speech". He describes this process of thinking where entire linear verbal schemes are contracted into their central themes.

The primary zone of unit three is Brodmann's area 4. This zone called the motor strip has the most direct link with the muscles. Impulses are sent to individual muscle fibers contralaterally. This region is arranged somatotopically with the most superior regions of the body (face, mouth) being controlled by the inferior aspects and the lower limbs being controlled by the superior and medial aspects. Like the somatosensory strip (post-central gyrus) the amount of neuronal space devoted to each muscular region is a function of the degree of control required by the region rather than the actual size of the region. Damage to this region results in the loss of fine motor control, speed and strength. Difficulties in this area are frequently manifested as a hemiplegia of effected regions on the contralateral side of the body.

Luria (1966) proposes that each area of the brain takes part in more than one functional system. He proposes that by analyzing the precise functional systems involved, the location of the injury to the brain can be determined. The connection between brain injury and hyperactivity was the research of Stewart, Pitts, Craig, and Dieruf (1966) who reported statistically significant differences between controls and individuals with hyperactive child symptoms. Differences in delayed speech development, speech problems, poor coordination, and strabismus suggested that brain dysfunction rather than psychological factors contributed to deficits in attention.

Golden (1988) noted that along with the three units of the brain discussed previously, the cerebral hemispheres, comprising the second and third Luria units can be further divided into left and right halves which have different functional roles. The right hemisphere has been associated with processing nonverbal material including visual-spatial

and musical stimuli (Bogen, 1975; Gazzaniga, 1975; Ornstein, 1972, 1973, 1978).

Subjects in this study completed the Gordon Diagnostic System (GDS) and portions of the Luria-Nebraska Neuropsychological Battery (LNNB) processing visual material. The primary function of the left hemisphere is the ability to control and understand verbal material (Kershner & King, 1974; Rourke & Telegdy, 1971; Rudel & Teuber, et al., 1974). In this study each subject was required to understand the verbal directions of the LNNB and the GDS.

Continuous Performance Tests

Rosvold, Mirsky, Sarason, Bransome, & Beck (1956) reported the classic tests from the Wechsler Scales (Digit Span & Coding) used to measure attention were inconsistent because the subject chooses when to respond. Such choices may allow the subject to reorganize his attention between momentary lapses. They developed a test requiring a high level of continuous attention over an appreciable interval of time which does not allow the subject to choose his own time to respond. They called their test the Continuous Performance Test (CPT), of which the GDS is one of the latest adaptations. The CPT is based on electroencephalographic evidence which suggests brain-damage in individuals on tasks requiring sustained attention or alertness (p. 343). Rosvold's (Rosvold, et al., 1956) results indicated individuals with known attention difficulties performed poorly relative to controls on tests requiring continuous attention. He was unsure whether to attribute his findings to an impairment in attention or momentary lapses in general arousal levels of subjects (p. 349). While Rosvold's study produced significant results it was considered preliminary and replications with different subject groups was suggested. One of the

difficulties in replicating this study was the size and expense of the apparatus it required. The invention of the microprocessor has changed the application of the CPT from the bulky apparatus described by Rosvold to light, portable, more precise microcomputers (Klee & Garfinkel, 1983).

Klee's (Klee & Garfinkel, 1983) research noted few studies attempted to correlate Continuous Performance Test (CPT) performance and other commonly used measures of inattention, concentration, reflectivity, impulsivity, and behavior. Klee's research revealed errors of omission and commission on CPT tasks correlated with the Arithmetic and Coding Scales of the WISC-R and with the Conners Rating Scales at significant levels.

Burg, Rasile, Davino, Major, Burright, & Donovanick (1992) conducted a study to determine the utility of the Gordon Diagnostic System in adult populations known to have deficits in attention. They noted normative data on the GDS for control subjects were comparable to the data collected by Gordon in 1988. The performance of adults with attention deficits was at or below the fifth percentile relative to the control population. They indicate their results suggest that the GDS is a useful tool for the assessment of attention deficits in adult populations (p. 2).

Models of Attention

Mirsky (1989) proposes a model where attention can be divided into a number of separate functions, including focus, execute, sustain, encode, and shift (p. 85). He notes these functions are supported by different brain regions, which have become specialized for this purpose but which nevertheless are organized into a system (p. 85). Mirsky proposed the function of focusing on environmental events is shared by superior-

temporal and interior-parietal cortices as well as by structures that comprise the corpus striatum, including the caudate, putamen, and globus pallidus (p. 85). In his model sustaining a focus on some environmental event is the major responsibility of the rostral midbrain structures including the tectum, mesopontine reticular formation, and midline and reticular thalamic nuclei (p. 86). An essential mnemonic function required for attention is that the hippocampus encodes considerable amounts of environmental stimuli and the "capacity to shift from one salient aspect of the environment to another is supported by the prefrontal cortex" (p. 86). Mirsky proposes that damage or dysfunction in one of these brain regions can lead to circumscribed specific deficits in a particular attention function (p. 86).

This study considered Mirsky's model of attention in the analysis of each subject's performance on the Gordon Diagnostic System and the Luria-Nebraska Neuropsychological Battery, Form 1, Adult version. Mirsky's model divides attention into separate components and these functions appear to be supported by specialized regions of the brain. His analysis of the elements of attention was based on data obtained from the National Institute of Mental Health where neurological tests were administered to neuropsychiatric patients and normal controls. The tests used in his analysis included:

1. The Trail Making Test (Reitan & Tarshes, 1959)-Time to complete.
2. Talland Letter Cancellation Test (Talland, 1965)-Number correct.
3. Digit Symbol Substitution Test (DSST) (subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R), (Wechsler, 1955)-Number correct.
4. Stroop Color-Word Test (Stroop, 1935)-Total time.

5. Continuous Performance Test (CPT) (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956; Mirsky & Van Buren, 1965)-Mean number of correct responses.
6. CPT-a. Mean number of errors of commission.
 - b. Mean reaction time for correct responses.
7. WAIS-R -a. Digit Span-Total score forward and backward.
 - b. Arithmetic-Highest score.
8. Wisconsin Card Sorting Test (<WCST> Grant & Berg, 1948)-Number of errors.

The Vigilance and Distractibility tasks of the Gordon Diagnostic System (GDS) provide norm referenced scores describing a subject's performance when attention and concentration are required. The primary purpose of the LNNB is to assist in the diagnosis of specific cognitive deficits, including lateralization and localization of focal brain impairments. The statistical analysis of each subject's performance on the GDS and LNNB aided in the understanding of aspects of attention related to difficulties in cognitive deficits and specific regions of the brain.

Hyperactivity

The history of our understanding of hyperactivity is considerably shorter than the debate which has raged for centuries regarding the seat of mental processes. In 1845, a German physician, Heinrich Hoffman (Hoffman, 1845), first described the hyperactive child syndrome in German children's book. His story told of the humorous activities of "Fidgety Phil: in pictures and doggerel verse." In the years that followed it became apparent that hyperactive children were not humorous to themselves, their families, their peers, or their school teachers. William James in 1890 (James, 1890) noted the inability to

sustain attention seemed related to poor control and impulsive behavior. He suggested a single neurological deficiency as the underlying cause. In 1902 Still (Still, 1902) attributed ADHD symptoms to defects in "moral control". Amaya-Jackson (Amaya-Jackson et al., 1992) noted the great influenza epidemic of 1917-18 left many people with serious neurological impairments. The aftereffects of the flu virus and the fever it had caused were seen in a group exhibiting increased motor activity, impulsivity, and inattention: the neurological symptom triad of ADHD. The term postencephalitic behavior disorder was used to describe these individuals who appeared to have suffered from a form of ADHD. Early definitions of hyperactivity stressed the presence of excess activity (Ounsted, 1955). Other authors suggested additional symptoms including short attention span, fluctuation of mood, aggressive outbursts, lack of fear and shyness, excitability, neurological dysfunction, and other emotional or behavioral problems (Werry, 1968; Ounsted, 1955). As a result of such classifications several authors stressed the quality of the motor activity in a person suspected of hyperactivity rather than the quantity (Hutt and Hutt, 1964; Keogh, 1971; McFarlin, Peacock, and Watson, 1966). Golden and Anderson (1979 p. 102) note hyperactive people may not actually be more active than others; however, their behavior may be more socially inappropriate and irritating in the eyes of others. Hyperactive people show more neurological symptoms during neurological examinations (Werry, 1968). For example, Luria (1966) noted individuals with lesions to prefrontal areas may be easily distracted by small noises or events that others ignore. The administration of a neuropsychological investigation and a performance based measure in this study attempted to assess several of the above observations.

Golden and Anderson (1979 p. 105) note hyperactivity may be related to brain damage in two important ways. First, hyperactivity may arise from damage in the area of the hippocampus, or through a dysfunction in the Reticular Activating Formation (RAF). The RAF theory has suggested the possibility of why individuals with hyperactivity respond well to stimulants. Stimulants raise the level of arousal in the RAF, thereby reducing the need for stimulation from external sources.

The Reticular Activating Formation (RAF) makes up a major part of Luria's first unit, being composed of several groups of nerve cells which are dispersed throughout the brain stem and other structures of the brain. The role of the RAF has been described as that of nonspecific (general) arousal (Papez, 1956), activation (Gastaut, 1958), and the induction of consciousness (Masland, 1958). The RAF is also involved in going to sleep and remaining alert during the day (Chusid, 1970). The work of Jasper (1957) indicates the midline thalamic region and the reticular nuclei play a role in attention.

Current Perspectives

Zametkin & Rapoport (1986) cite several theories which implicate the dysfunction of arousal-frontal inhibitory area of the brain in individuals with attention-deficit disorders (e.g. Dykman, Ackerman, Clements, & Peters, 1971; Dykman, Ackerman, & McCray, 1980; Dykman, Ackerman, & Oglesby, 1979; Wender, 1974). The validity of this hypothesis was supported by a computerized tomography (CT) study in which regional cerebral blood flow (rCBF) was monitored in subjects diagnosed as having attention-deficit disorder with and without stimulant medication. When compared with normal subjects, ADHD subjects possessed a hypoactive frontal-inhibitory system when not taking stimulant

medication (Lou, Henriksen, & Bruhn, 1984). A more recent study (Lou, Henriksen, Bruhn, Borner, and Nielsen, 1989) using the same procedures found differences between subjects with ADHD only and those who presented with co-occurring ADHD and other neurological symptoms (mild mental retardation, dysphasia). The ADHD only subjects results indicated hyperfusion only in the right striatum while subjects with ADHD and co-occurring neurological symptoms results indicated bilateral hypoperfusion. The study indicated that low striatal activity was characteristic of children with ADHD and reversible with the administration of methylphenidate (Ritalin).

A study by Grodzinsky (1990) noted ADHD reflected a continuum of deficits in inattention, impulsivity, and motor restlessness. She noted Luria's perspective regarding verbal regulation of behavior appeared to capture several of the difficulties observed in subjects with ADHD. Luria suggested that there is a disruption in the control of functions which plan or program behavior. He postulated the disruption of feedback mechanisms, which normally permit self-evaluation, leads to a loss of the ability to benefit from self-reinforcement and increases the incidence of impulsive, restless and inattentive behavior. ADHD individuals lack self-conscious participation and self-regulation in their actions. Such behavior is similar to the self-monitoring deficits seen in people with frontal lobe dysfunction. The results of Grodzinsky's study provided partial support for the hypothesis that clinical similarities exist between frontal lobe dysfunction and ADHD. Subjects with hyperactivity performed in accordance with deficits seen in prefrontal lobe dysfunction and significantly different from the control group. The GDS was part of this study but the LNNB was not. However, Luria was cited as emphasizing the verbal regulation of motor

behavior as a primary function of the frontal lobes (pp. 4 & 5). Further research in this area was recommended with other neuropsychological instruments. The use of the LNNB in this study addressed some of the concerns raised in Grodzinsky's study.

Grant, Ilai, Nussbaum, & Bigler (1990) compared the Gordon Diagnostic System with selected subtests from the Halstead-Reitan Battery. A significant correlation ($p < .001$ level) was found between the Vigilance task of the GDS and the Finger Recognition Task of the Halstead-Reitan which suggested a relationship between various sensory-motor tasks and measures of sustained attention. The authors concluded that inferences about intact or dysfunctional attention are frequently based on neuropsychological or intellectual test performance and yet few neuropsychological measures are designed to specifically assess attentional constructs. Grant, (Grant et al, 1990) noted the paucity of research describing the relationship between objective measures of attention and other tests used to infer attentional functioning. This study attempted to address the lack of such research.

Current perspectives on the role of the corpus callosum highlight its participation in interhemispheric regulation, possibly through inhibitory or excitatory influences in modulating cerebral activity (Lassonde, 1986). For example, a study by Hynd, (Hynd et al., 1991) which incorporated magnetic resonance imaging (MRI) provided initial support for the notion that significant differences exist in the corpus callosum of children with ADHD. This study was seen as partially confirming the research by Dykman (Dykman et al., 1971) who postulated children with ADHD possessed deficient frontal systems. The ADHD children in Hynd's study had significantly smaller ($p < .01$) portions of the corpus callosum interconnected with the premotor and prefrontal regions.

A 1996 study by Murphy and Barkley compared biological parents of ADHD children with parents of nonclinical children. Impairment in social and psychological functioning was noted for the parents of children with severe ADHD. No significant differences were found on measures of sustained attention, memory, cognitive flexibility, encoding or impulsivity. Current adaptive functioning rather than laboratory test were suggested as more useful assessment measures. This study incorporated measures of adaptive functioning along with performance based measures in assessing possible differences in families with ADHD members.

Summary

In this chapter early theories of brain-behavior relationships were reviewed. Similarities and differences regarding traditional theories of neuropsychology were defined including the localization and equipotential approaches. The development of Luria's functional system approach to neuropsychology was described. Luria's three major units necessary in nearly every functional system were identified and located within the brain. The neurodynamics relating to attention along with the effects of dysfunction or damage to each unit were listed. The initial investigations correlating attention problems and brain dysfunction and the hemispheric division of Luria's second and third units by Golden and others were reviewed. The development of continuous performance tasks along with models of attention and concentration related to this study followed. The history relevant to our understanding of hyperactivity along with possible relationships to brain injury, hyperactivity, inattention, concentration and distractibility difficulties were reviewed. Current perspectives regarding specific structural aspects of brain-behavior relationships

and the need for research utilizing valid, objective measures of attention, concentration and brain dysfunction were cited.

Chapter 3

This chapter describes the population and the sample, including selection and size, procedures and data gathering, instrumentation, research design and statistical analysis.

Sample description

The target population for this study is urban families in the United States with members who have a diagnosis of Attention-deficit Hyperactivity Disorder. The accessible population for this study are families with members diagnosed as Attention-deficit Hyperactivity Disorder who frequent private mental health facilities in Southeastern Virginia. The subjects in this study consisted of two groups of adults randomly selected from Southside Hampton Roads and the Peninsula of Virginia. Randomness was achieved by drawing subjects from lists of referrals generated since 1989. The subjects had no previously diagnosed impairments (vision, hearing or physical abnormalities) which would affect performance on evaluation instruments. The experimental group consisted of the biological parents of a child diagnosed with Attention-deficit Hyperactivity Disorder (ADHD). The control group, selected from the general public, were adults who had at least one child and none of their children had any known history of ADHD.

Requests were made to local churches and schools to recruit the control group. The breakdown of those requests by city were as follows:

Chesapeake	24	Portsmouth	17
Hampton	14	Surry	3
Newport News	27	Virginia Beach	14
Norfolk	6		

A copy of the request form is located in appendix 1.

Because this study investigated families with a child who exhibited ADHD symptoms information was gathered over three generations. Information about each subject's family of origin is described first. The current status of each subject with regards to demographic data is followed by a brief description of their children.

Subjects provided information about the size of their birthplace and the educational and occupational levels of their parents. Other historical data included responding to behavioral descriptors as children using a Likert scale 1 (no evidence of behavior) through 4 (frequent evidence of behavior).

Current status of the subjects included the following:

In the control group 90 % of the subjects were white and 10 % black. 100% of the experimental group were white. The average age of the control group for this study was 39.7 years (SD 7.0). The average age of the experimental group was 40.34 years (SD 6.21). 85 % of the control group was right handed (15% left handed) and 82% of the experimental group was right handed (18% left handed). The average educational level of the control group was 14.92 years (SD 2.22). The average educational level of the experimental group was 13.94 years (SD 1.97). The income level of each subject was recorded along with their current occupational levels and current religious preferences.

When the Children of the subjects in this study were examined the following breakdown was evident.

FIRST CHILD

The average age of the first born child in the control group was 13.6 years (SD 7.17). The first born children in the experimental group had an average age of 14.35 years (SD 5.63). 60 % of the first born children in the experimental group had a diagnosis of ADHD.

SECOND CHILD

The average age of the second child in the control group was 11.89 years (SD 7.48). The second born child in the experimental group had an average age of 10.83 years (SD 6.43). 29% of the second children in the experimental group had a diagnosis of ADHD.

THIRD CHILD

The average age of the third child in the control group was 11.57 years (SD 6.92). The third child in the families of the experimental group had an average age of 9 years (SD 7.34). 18% of the third born children in the experimental group had a diagnosis of ADHD.

Data gathering

Both groups were administered the Gordon Diagnostic System (GDS) and the Luria-Nebraska Neuropsychological Battery (LNNB), Form 1. The researcher interviewed each participant and described the study in detail. The interview (see appendix 1) determined if there was any known family history of ADHD and the extent that any physical difficulty might effect performance on the evaluation instruments. The group with a child diagnosed as ADHD was randomly selected from the researcher's private practice and other referral sources. Each subject read and signed the informed and voluntary consent form which detailed the amount of time involved to complete the evaluation instruments and how information regarding results was disseminated.

Instrumentation

What follows is an explanation of The Gordon Diagnostic System (GDS) and the Luria-Nebraska Neuropsychological Battery (LNNB) along with information regarding the reliability and validity of each instrument.

The Gordon Diagnostic System for adults consists of two tasks:

I. The Vigilance task

The Vigilance task requires a subject to respond to specific combinations of stimuli embedded in a series of random digits. The subject is required to respond each time a "9" immediately follows a "1". The internal computer tracks the number of correct responses, the amount of time between the presentation of the target stimuli and the subject's response (response latency in milliseconds), as well as the number of times the subject responds to other than the appropriate combination of digits (errors of commission). Errors of omission are also recorded.

The Vigilance task measures concentration and arousal which requires that the subject achieve and maintain a high level of alertness. This level of responding must be maintained in the absence of feedback. The subject's responses are recorded for three contiguous two minute blocks of time.

2. The Distractibility Task

This task is similar to the Vigilance task, however, the subject must ignore stimuli presented to the right and left of the target combination of digits. The subject must respond for three, contiguous two minute blocks. Scores are recorded for correct responses, time between presentation of the stimulus and subject's response, and errors of commission and omission.

The Luria-Nebraska Neuropsychological Battery. (LNNB), Form I, Adult

The Luria-Nebraska Neuropsychological Battery (LNNB) is based on Luria's 1966 concept of functional systems. Each test is relatively independent. Items differ in terms of familiarity, complexity, method of response, the demands of attention and concentration required (an important concept considering the nature of this study), and speed of response. Moses, Golden, Ariel, & Gustavson (1983), describe the LNNB as 269 tests rather than 269 scores, with each test evaluating a different functional system. As noted previously no item was described as "pure" measuring only one psychological ability. Each item is described as measuring the functions of numerous areas of the brain.

In 1951 Luria published a summarized version of his investigative techniques which was translated into English by Dr. Lawrence Majovski. Anne-Lise Christensen, in 1957, published a set of materials she developed by observing and documenting some of Luria's clinical assessment procedures. The original scales for the LNNB were derived from these sources and from Luria's broad categories for his own terms. Luria determined an item's classification on the basis of its intent. Scores of 0 indicate that a subject's performance

falls within the normal range of variability; scores of 2 indicate performance in the brain-damaged range. A score of 1 suggests an intermediate response falling between the normative performance of normals and brain impaired patients (Golden, 1979).

Golden, Purisch, and Hammeke (1988) described the composition and function of each LNNB clinical scale as follows:

1. **Motor Scale.** This scale is designed to measure basic fine motor speed, unilateral and bilateral coordination, imitation of movement, verbal control of motor movement, and construction skills. Moses, Golden, Ariel, & Gustavson (1983 p.7) note this scale allows the examiner to determine the degree to which there are disturbances in attention and concentration.

The nature of the items on the motor scale are sensitive to different types of brain dysfunction. Primary sensitivity is to sections of the posterior frontal lobe, but lesions of the temporal and parietal lobes as well as dysfunction of the anterior frontal lobe, will result in significant elevations (Golden, Purisch, & Hammeke, 1988 p. 137).

2. **Rhythm Scale.** Items on this scale evaluate the subject's ability to make simple tonal discriminations, maintain a melodic pattern in signing, count tones, and to reproduce simple rhythmic patterns. Impulsive individuals and those with attention problems may require assistance with this scale and the type and amount of assistance required will provide clues to the type and extent of the subject's attention problems.

Difficulties with this scale, in the absence of speech problems, is usually indicative of right hemisphere impairment. If the rhythm scale scores are the highest in a subject's

profile they are frequently associated with impairment of the anterior right hemisphere (frontal or temporal lobes) (Golden, Purisch, & Hammeke, 1988 p. 138).

3. Tactile Scale. This scale assess tactile sensitivity by requiring location of stimuli, a 2-point discrimination, pin prick and pressure sensation, movement detection, graphesthesia, and stereognostic skills in both the right and left hands and arms. Moses, Golden, Ariel, & Gustavson (1983) note problems with attention and concentration may interfere with a valid and reliable administration of this scale.

This scale is most sensitive to injuries within the anterior parietal lobe of either hemisphere. The tactile scale is highly sensitive to residual effects of brain injury even when other skills have improved. Difficulties with integrating and identifying stimuli on this scale may result from an inability to concentrate (Golden, Purisch, & Hammeke, 1988 pp. 138-139).

4. Visual Scale. Items on this scale are designed to assess simple visual recognition from actual objects as well as from pictures, identification of pictures presented in an indistinct fashion or in an overlapping array, and the use of spatial relationships.

Elevations on the visual functions scale are associated with left hemisphere disorders, particularly within the temporal-parietal areas. Items within the later portions of the scale are sensitive to visual-spatial organization and right hemisphere functioning if the subject is able to perceive the questions (Golden, Purisch, & Hammeke, 1988 p. 139).

5. Receptive Language Scale: Assess a subject's ability to discriminate phonemes, to follow simple commands, and to understand more complex grammatical structures.

Moses (Moses, Golden, Ariel, & Gustavson, 1983) notes disturbances in attention and concentration can cause elevations on this scale.

Elevations on the receptive speech scale resulting from difficulties repeating simple phonemes suggests impairment within the angular gyrus. Difficulty responding to items containing complex instructions suggest damage to the left hemisphere. Subject's who have difficulty making comparisons may have damage within the parietal-occipital areas of the left hemisphere (Golden, Purisch, & Hammeke, 1988 p. 140).

6. Expressive Language Scale: Evaluates a subject's ability to correctly repeat simple words and sentences presented orally and visually, to use automatic speech, to name objects from visual and oral descriptions, and to initiate verbal responses from several stimuli.

Impairment in the frontal lobe area can elevate a subject's score on this scale. In general expressive speech scale scores are sensitive to injuries within the left hemisphere. If a subject has difficulty only with the more complex items on this scale damage to the prefrontal area is suggested (Golden, Purisch, & Hammeke, 1988 pp. 140-141).

7. Writing Scale: This scale is comprised of items which test the ability of a subject to analyze letter sequence, to spell, to copy, and to write from dictation.

Disorders of writing localize within the temporal-parietal-occipital area in and around the angular gyrus of the left hemisphere (Golden, Purisch, & Hammeke, 1988 p. 141). The type of errors made by subject's may provide further information as to the specific area of the brain involved. For example, a subject able to write from dictation but not

from written material may have an injury in the occipital-parietal areas of the cerebral cortex.

8. Reading Scale: Items on this scale measure letter recognition, sound synthesis, nonsense syllable reading, and word, sentence, and paragraph reading.

Disruption of the skills required to complete this scale implies lesions within the temporal-occipital area of the brain or within the parietal area of the left hemisphere (for a right handed individual). If a subject reads simple words but not sentences or paragraphs, disorders of visual scanning are suggested due to injuries within the secondary visual areas of the occipital lobe (Golden, Purisch, & Hammeke, 1988 p. 142).

9. Arithmetic Scale: Items are designed to evaluate number recognition and writing, number comparison, and simple mathematical processes. Moses, Golden, Ariel, & Gustavson (1983 pp. 36-37) note the importance of observing the qualitative nature of a subject's deficits as arithmetic problems tend to be sensitive to an extremely wide range of injuries in both hemispheres, as well as subcortical areas of the brain involving attentional factors.

This scale is the most sensitive to educational deficits. If difficulty on this scale is the result of sequencing problems, deficits within the right hemisphere or left occipital-parietal areas are suspected. Concentration difficulties on this scale are frequently associated with left frontal lobe dysfunction (Golden, Purisch, & Hammeke, 1988 p. 142).

10. Memory Scale: This scale evaluates verbal and nonverbal memory with and without interference. This scale allows no stimulus repetitions, therefore errors are thought to result from a lack of concentration and attention or an inability to input the information.

The first items on this scale require a subject to memorize a list of words and predict his or her performance. The inability to predict is frequently seen in subjects with frontal lobe dysfunction. Several items within this scale require a subject to cope with interference while memorizing. Injuries to the bilateral hippocampal area will be evident in items involving interference (Golden, Purisch, & Hammeke, 1988 p. 143).

11. Intelligence Scale: This scale is comprised of items similar to those on the Picture arrangement, Picture Completion, Vocabulary, Comprehension, Arithmetic, and Similarities subscales of the Wechsler Intelligence Scale for Children-Revised (WISC-R). Other items on this scale measure a subject's ability to make simple generalizations and deductions. It was noted that the lack of extremely difficult items limits the LNNB from estimating IQ's higher than 115.

Difficulties with the initial items on this scale are associated with frontal lobe dysfunction. This scale is highly sensitive to disorders in both hemispheres but most sensitive to disorders within the left hemisphere (Golden, Purisch, & Hammeke, 1988 pp. 143-144).

Reliability & Validity

Reliability

Anastasi (1988) describes the concept of test reliability as the extent to which individual differences in test scores are attributable to “true” differences in the characteristics under consideration and the extent to which they are attributable to chance error.

Reliability of the Luria-Nebraska Neuropsychological Battery (LNNB).

Split-Half Reliability

Golden, Moses, Fishburne, Engum, Lewis, Wisniewski, et al. (1981 p. 304) examined the split-half reliability and item consistency of the LNNB. Odd-even splits were used to determine the split-half reliability which ranged from .89 (Memory) to .95 (Reading). Both Pearson Product-Moment and Correlation Ratio correlation's were computed. The correlation's are computed if the scattergrams for research data indicate that the relationship between two variables is markedly nonlinear. The advantage of correlation ratio computations is that they provided a more accurate index of the relationship between two variables than other correlational statistics (Borg and Gall, 1989 p. 597). No item on the LNNB failed to correlate significantly ($p < .01$) with the corresponding scale. The study by Golden, Moses, Fishburne, Engum, Lewis, Wisniewski, et al. (1981 p. 305) demonstrated the statistical basis of the LNNB as sound and more than adequate for confidence in clinical interpretation and validation studies.

Internal Consistency

Mikula (1981) reported internal consistency estimates ranging from .82 on the Rhythm scale to .94 on the Motor scale. He used a sample of 146 brain damaged subjects. The clinical, summary, and localization scales of the LNNB were found to be internally consistent, when analyzed using Cronbach's Alpha statistic. Cronbach's Alpha is a general form of the Kuder-Richardson 20 formula (Borg & Gall, 1989 p. 261). Moses (1985) demonstrated that all the LNNB clinical scales exceeded the 0.80 of internal consistency using the same Cronbach's coefficient alpha statistic. The Cronbach standard was recommended by Nunnally (1978) because it reduces error variance to a practical minimum. Nunnally also recommended demonstration of a moderate correlation (with minimum correlational value of 0.25) between an item and the total score of the scale to which it has been assigned. Using this criterion each item should contribute in a significant but nonredundant manner to the total scale score. Moses (1987) demonstrated that 257 of the 269 LNNB items met or exceeded the minimum value item-to-scale score criterion for the LNNB clinical scales.

Inter-rater reliability

Moses and Schefft (1985) investigated the inter-rater reliability of the LNNB. At the item level the two raters agreed exactly on approximately 96% of the LNNB items. This finding was achieved despite the large difference in personal experience with the scale between the two raters.

Test-Retest

A test-retest study in 1982 (Golden, Berg, and Garber, 1982) indicated the lowest reliability's were found on the Tactile Functions scale (.78) and the Right Hemisphere (.77). The highest reliability was noted in the Arithmetic scale (.96). Interval between test and retest averaged 167 days (SD=134) days) with a range from 10 to 469 days. A further study of test-retest reliability was reported in 1982 (Plaisted and Golden, 1982). Test-retest reliability's for the 14 clinical scales ranged from .83 (Memory) to .96 (Arithmetic).

Moses & Maruish (1987) noted the reliability studies conducted through 1986 identified the LNNB as a reliable instrument. Interrater studies indicated a high degree of scoring agreement between raters. Test-retest studies demonstrated the LNNB yielded estimates of neuropsychological functioning which were stable over time. Moses (1987) performed an item-analysis on a large sample of subjects (1,544) who had received the LNNB and found all items correlated with their respective corrected total scale scores beyond the 0.0005 level of statistical significance.

The Gordon Diagnostic System (GDS)

Reliability

Gordon and Mettelman (1988) presented test-retest reliability on 90 children randomly selected from the standardization sample of the GDS who were retested between 30 and 45 days and 1 year after the initial administration. The authors reported all correlations are significant at the $p < .001$ level. When the test-retest interval was 2 to 22, days the

correlations ranged from .67 on the total correct number of responses to the distractibility task to .84 for the total number of commission errors during the vigilance task.

Validity

Anastasi (1988) describes validity as what the test measures and how well it measures a certain construct. The trait measured by a given test can be defined only through an examination of the objective sources of information and empirical operations utilized in establishing its validity.

Validity of the Gordon Diagnostic System (GDS)

Concurrent Validity

Grant, Ilai, Nussbaum, & Bigler (1990) stressed the concept of concurrent validity in a study which examined the relationship between measures of sustained attention and impulsivity (GDS) and a battery of intellectual, achievement, and neuropsychological tests. They noted low to moderate correlations among measures specifically designed to assess attention and impulse control, and traditional measures used to assess attentional functioning, such as the Freedom from Distractibility factor of the WISC-R. The correlations between the GDS vigilance task and the Freedom from Distractibility factor of the WISC-R were equal to $r = .28$. This correlation was significant at the $p < .01$ level. Correlations between the GDS distractibility task and the WISC-R Distractibility factor were equal to $r = .44$. This correlation was significant at the $p < .001$ level. Such findings, they state, support the concurrent validity of continuous performance tests and at the same

time suggest the uniqueness of these tests. The author's indicated the need for further research to clarify the relationships between continuous performance variables in individuals with ADHD disorders.

Kashden, Haut, & Franzen (1990) conducted a study where the GDS was correlated with several measures of attention problems and the various tasks of the GDS were intercorrelated with each other. The distractibility commission score was significantly related to the vigilance commission score ($r = -.38, p < .05$) and the Vigilance Correct Score ($r = .40, p < .05$). They noted the intercorrelations between GDS tasks can be interpreted as supportive of construct validity, with the domain of attentional processes being tapped by all three tasks. Further investigation of the GDS and other measures of attention was recommended.

Validity of the Luria-Nebraska Neuropsychological Battery (LNNB)

Concurrent Validity

Diamant (1981) conducted a theoretical and empirical comparative study of the original Lurian syndrome analytic methodology and the Halstead-Reitan Neuropsychological Battery actuarial approach with the same group of psychiatric patients with brain dysfunction. He also considered the initial work on the LNNB which was available through 1979, but did not include this in his comparison of the original methodologies. He found that the Luria and Halstead-Reitan methods produced very similar and useful results in his population. Diamant (1981) also emphasized the particular complementary strengths of each theoretical approach. Anastasi (Anastasi, 1988 p. 495) noted available

validation data on the Luria-Nebraska battery indicated a high level of success in screening for brain damage and promising results in localizing the damaged areas.

Shelly and Goldstein (1982b) conducted an experiment which empirically compared the Halsted-Reitan Neuropsychological Battery (HRNB) with the Luria-Nebraska Neuropsychological Battery (LNNB). The authors reported a correlation of $r = .82$ between the impairment level of the Halstead-Reitan and the LNNB average T-scores. Their findings suggested that both batteries assessed comparable domains of function which included language, nonverbal cognitive abilities, and perceptual-motor skills.

Ryan and Prifitera (1982) investigated the concurrent validity of the Luria-Nebraska Neuropsychological Battery (LNNB) Memory Scale and the Wechsler Memory Scale (WMS). They concluded the WMS yielded a significant correlation with the LNNB ($r = -.65$ $p < .001$) using a Pearson product moment correlation. They found 72% agreement between the two memory scales indicating 52% of shared variance between these two instruments. Moses and Maruish (1988b) noted investigations of the concurrent validity of the LNNB Memory Scale with other tests of short-term memory, while exploratory, were supportive of the validity of the LNNB scale as a measure of short-term memory.

Construct Validity

Blackerby (1985) incorporated item response theory (IRT) to investigate the theoretical construct or "latent trait" of the Luria-Nebraska Neuropsychological Battery's clinical scales. Using the two-parameter IRT model, Blackerby noted satisfactory estimates of LNNB clinical scale dimensionality. Statistical criteria for scale unidimensionality and

accuracy across a wide ability range were also met by each of the LNNB clinical scales. He noted "unidimensionality is a property of the responses to the items rather than of the items themselves. If responses to the item are made on the basis of the underlying trait under consideration, then the items and the scale will be unidimensional" (p. 24). This study also recommended some minor modification of clinical scale item assignment and that the elimination of some items appeared warranted.

A factor analytic study by Moses (1986) divided the LNNB item pool into sensorimotor (Motor, Rhythm, Tactile and Visual Scale items as a group), speech (Receptive Speech, Expressive Speech, Writing and Reading items as a group), and conceptual (Arithmetic, Memory and Intellectual processes items as a group). The items from each band were factor analyzed separately, rotated to simple structures by means of the orthogonal Equamax method, and submitted to the same internal consistency analyses by means of coefficient alpha. Considering very few cross-scale factors were identified, this study was seen as supporting the findings reported by Golden (1981).

Moses and Maruish (1987, 1988a,b) surveyed reliability and validity literature which was published or presented at professional meetings from 1976 through 1986. They cited studies which reported replicated evidence in support of a stable factorial structure for the LNNB clinical and summary scales across large, heterogeneous samples. They concluded available evidence supported the construct validity of the LNNB clinical scale measures.

Research Design

This study compared two samples of adults that differed on the presence or absence of a child diagnosed as ADHD, but are otherwise comparable (Borg & Gall, 1989 p. 5 & 6).

The following null hypotheses will be explored in this study:

1. There will be no statistical difference between control and experimental subjects on measures of attention and concentration.
2. There will be no statistical difference between control and experimental subjects on tasks measuring distractibility.
3. There will be no significant elevations on the Luria-Nebraska Neuropsychological Battery (LNNB), Form I Adult version for individuals with borderline or abnormal scores on the Gordon Diagnostic System.

Statistical Analysis

The first step included the computation of descriptive statistics for the experimental and control groups in this study. These included group means and standard deviations (Borg & Gall, 1989 p. 546). T-tests were calculated between all groups on all GDS task Scores. For those subjects with abnormal or borderline GDS scores, LNNB protocols were examined for the presence of scale elevations. An alpha level of .05 was used for all statistical tests.

Committee on Human Subjects Research Criteria

During the informing interview each subject read and signed a permission form for the study. The subject's right to withdraw from the study at any time was guaranteed in writing. (See Appendix 1).

Chapter 4

Results

This section explains the statistical methodology employed in this study, reviews the historical and demographic information compiled for each subject, enumerates the research hypotheses, presents the results of the statistical analyses and reports the acceptance or rejection of the null hypotheses.

The methodology employed to evaluate the degree of statistical significance between the control group and experimental group was a t-test for independent means. For hypothesis three a difference of proportions test was used. The Microsoft Excel 5.0 spreadsheet program was used to tabulate the over 10,000 data points in this study. For the various measures the mean, standard deviation and variance were compiled and then chi-square, t-tests or a difference of proportions tests was performed. When appropriate, the groups were evaluated for differences between males and females and t-tests were performed.

Demographics

No significant differences were found for birthplace when subject's responses were evaluated using a chi-square analysis $\chi^2(2, N = 88) = 1.58, p < .99$. A chi-square analysis of the educational level of each subjects mother was not significant $\chi^2(3, N = 93) = 8.41, p < .10$. Significant differences in the educational levels of their fathers $\chi^2(4, N = 92) = 24, p < .01$, were reported by subjects in this study. When parental occupations of subjects in this study were examined, using a chi-square analysis, no significant differences

for mothers $\chi^2(3, N = 93) = .97, p < .95$, or fathers $\chi^2(2, N = 91) = 2.28, p < .90$ were noted. No significant differences between the control and experimental groups were found for current income levels $\chi^2(3, N = 93) = 3.85, p < .90$, occupational levels $\chi^2(2, N = 93) = 5.72, p < .10$, religious preferences $\chi^2(1, N = 93) = 1.4, p < .90$, or educational levels $\chi^2(4, N = 93) = 8.45, p < .10$ (see Appendix 2). Symptoms of ADHD appear early in life. Therefore, each subject was asked to complete a behavioral checklist consisting of the items from the Connors scale that are scored for attention problems (Goyette, Conners, & Ulrich, 1978). The following results were noted:

Table 1

Historical Behavioral Checklist

Item Description	Experimental Group (N=50)		Control Group (N=44)		t-score	p value
	Mean	(SD)	Mean	(SD)		
Excitable and impulsive	2	.98	1.88	.91	0.59	< .55
Have difficulty with learning	1.94	.99	1.41	.90	2.6	< .01
Restless in the "squirmy" sense	2.3	.99	1.46	.70	4.65	< .001
Restless, always up and on the go	2.4	1.08	1.76	.97	2.9	< .004
Fail to finish things	2.16	1.14	1.56	.70	2.91	< .004
Childish or immature	1.7	.91	1.12	.39	3.78	< .002
Distractibility or attention span a problem	1.98	1.11	1.44	.77	2.62	< .01
Easily frustrated in efforts	2.2	1.03	1.41	.69	4.17	< .001
Mood changes quickly and drastically	1.86	1.08	1.49	.76	1.82	< .07
Denied mistakes or blamed others for mistakes	1.78	.76	1.48	.67	0.31	< .75

Other Findings

The original study involving the diagnostic efficiency of the test items in the Luria-Nebraska Neuropsychological Battery (LNNB) was conducted by Golden, Hammeke & Purisch in 1978. In this study the control group consisted of 50 individuals 26 females and 24 males. The average age of these subjects was 42.0 years (SD 14.8). The average age of the control group in this study was 39.55 years (SD 6.86).

In the original study of the LNNB the average educational level of the control group was 12.2 years (SD 2.9). In this study the average educational level of the control group was 14.81 years (SD 4.96).

The control group in the original study achieved t- scores = 50 (SD 10). In this study the t scores and standard deviations were as follows:

Table 2

Comparable Populations LNNB

	Original Control Group (N = 50)	Present Study's Control Group (N = 42)		t Score
	Mean	Mean	(SD)	
C-1	50	38.7	4.07	6.78*
C-2	50	39.34	8.9	5.31*
C-3	50	42.36	5.9	4.31*
C-4	50	41.7	6.39	4.59*
C-5	50	41.48	5.19	4.93*
C-6	50	37.73	5.95	6.91*
C-7	50	50.07	6.76	0.03
C-8	50	45.73	5.47	2.44**
C-9	50	47.26	8.79	1.37
C-10	50	42.12	8.3	4.03*
C-11	50	43.53	12.45	2.74***

* p < 0.001 ** p < 0.01 *** p < 0.01

A study to cross validate the results of the initial 1978 study was conducted by Moses and Golden in 1979. The results of the 1979 study were almost identical to the results of the 1978 study. It would appear the control group in this study was significantly less impaired than the original control group in all measured areas with the exception of Arithmetic (C9) and Writing (C7).

Gordon Diagnostic System

In the Spring of 1991 Andrew J. Saykin conducted a study where he reported the means and standard deviation of his control group. They were as follows:

Table 3

Comparable Populations GDS: Saykin Study

Vigilance Task	Saykin Study (N=30)		Present Study (N=42)		t
	Mean	SD	Mean	SD	
Total Correct	29.7	0.52	29.58	1.16	0.52
Total Commissions	0.72	1.55	0.24	0.54	1.84
Response Time	38.2	8.74	46.63	7.46	- 4.73*
Distractibility Task					
Total Correct	26.45	4.54	25.65	6.53	0.57
Total Commissions	2.0	2.94	2.16	5.80	- 0.13
Response Time	40.5	7.47	42.58	6.41	1.5

* p < 0.001

Saykin reported the educational level of his subjects as 14.3 years (SD 1.8). For this study the educational level of the control group was 14.81 years (SD 2.22).

A study by Burg, et al, 1992 reported the following information:

Table 4

Comparable Populations GDS: Burg Study

Vigilance Task	Burg Study (N=44)		Present Study (N=42)		t
	Mean	SD	Mean	SD	
Total Correct	30	1	29.58	1.16	1.79
Distractibility Task	(N=44)		(N=42)		
Total Correct	26	5	25.65	6.53	0.27

It would appear that the control group in this study was comparable to the control groups used in the normative studies of the GDS with the exception of reaction time to the Vigilance Task which was slower for the control group of this study.

Since the purpose of this study was the evaluation of the behavior and performance of subjects who came from families with or without a member previously diagnosed with ADHD the following null hypotheses were offered.

Hypothesis One:

There will be no statistical difference between control and experimental subjects on measures of attention and concentration.

This first hypothesis was rejected when the total mean response time of subject's was measured using the Gordon Diagnostic System's test of Vigilance.

Table 5

GDS: Vigilance Response Time

Mean Response Time in Milliseconds			
	Experimental Group (N=50)	Control Group (N=42)	
Mean Time	50.18	46.63	$t = 1.90, p < .05$
Standard Deviation	9.86	7.46	
Variance	97.17	55.59	

The Gordon Diagnostic System provides time measurement data for the length of the Vigilance task in three contiguous two minute time blocks. Considering difficulty with sustained attention or completing activities is a symptom of ADHD, each subject's performance over time was evaluated. Each two minute time block was examined, and significant differences between the experimental and control groups were found in time block number two.

Table 6

GDS: Vigilance Response Time: Time Block #2

Time Block #2			
	Experimental Group (N=50)	Control Group (N=42)	
Mean Time	50.48	46.73	$t = 1.92, p < .05$
Standard Deviation	10.2	7.96	
Variance	104.13	63.45	

Hypothesis one could not be rejected when other vigilance tasks were examined (see Table 7).

Table 7

GDS: Vigilance Summary

	Experimental Group (N=50)		Control Group (N=42)		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Correct	29.26	2.7	29.58	1.16	- 0.71	< .48
Commissions	.38	0.85	0.24	0.54	0.91	< .36
B-1 Correct	9.82	0.39	9.8	0.56	0.2	< .84
B-1 Om. Er.	0.18	0.39	0.2	0.56	- 0.1	< .92
B-1 Com. Er.	0.22	0.55	0.24	0.49	- 0.15	< .88
B-2 Correct	9.73	1.3	9.9	0.49	- 0.93	< .35
B-2 Om. Er.	0.26	1.3	0.1	0.49	0.74	< .46
B-2 Com. Er.	0.08	0.34	0	0	1.48	< .14
B-3 Correct	9.73	1.44	9.88	0.41	- 0.65	< .52
B-3 Om. Er.	0.27	1.44	0.12	0.41	0.65	< .52
B-3 Com. Er.	0.08	0.37	0.02	0.16	1.07	< .28
Commission Errors						
19X	0.14	0.41	0.02	0.16	1.77	< .07
XX9	0.02	0.14	0.02	0.16	0	< 1.0
XX1	0.1	0.31	0.17	0.44	- 0.89	< .37
X1X	0.04	0.2	0.02	0.16	0.54	< .59
X9X	0.08	0.45	0.05	0.22	0.39	< .7
XXX	0		0			
Response Latency						
B-1 Time	50.88	10.71	47.80	10.01	1.4	< .16
B-2 Time	50.49	10.2	46.73	7.96	1.92	< .05
B-3 Time	48.47	12.53	45.36	6.71	1.43	< .16
Mean Time	50.18	9.86	46.63	7.46	1.95	< .05

According to Golden, Purisch, and Hammekke (1988), the C-2 (Rhythm) scale of the Luria-Nebraska Neuropsychological Battery, Form I, Adult Version is the most sensitive of all the clinical scales to disorders of attention and concentration (pg.138). When the performance of the control and experimental groups were examined, hypothesis one could not be rejected.

Table 8

LNNB: C-2 Rhythm Scale

C-2 Rhythm Scale

	Experimental Group (N=50)	Control Group (N=42)	
Mean	37.7	39.34	t = - .88, p < .37
Standard Deviation	8.69	8.9	
Variance	75.6	79.23	

Other clinical, summary, and lateralization scales are described in the LNNB literature as sensitive to disorders of attention and concentration. As Table 9 demonstrates, hypothesis one could not be rejected when the performance of the control group and experimental group was subjected to statistical analysis.

Table 9

LNNB: Summary**Luria-Nebraska Neuropsychological Battery (LNNB)**

	Experimental Group (N=50)		Control Group (N=42)			
Clinical Scales	Mean	(SD)	Mean	(SD)	t - score	p - value
C-1	38.7	4.95	38.71	4.08	0.01	< .99
C-2	37.7	8.69	39.34	8.9	- 0.88	< .38
C-3	43.68	7.48	42.36	5.94	0.91	< .36
C-4	43.48	6.01	41.7	6.4	1.36	< .17
C-5	39.8	6.01	41.49	5.19	- 1.43	< .16
C-6	38.4	5.2	37.73	5.96	0.57	< .56
C-7	50.1	6.81	50.07	6.77	0.02	< .98
C-8	45.62	5.45	45.73	5.48	- 0.09	< .92
C-9	48.44	9.7	47.27	8.79	0.59	< .55
C-10	43.94	7.68	42.12	8.34	1.08	< .28
C-11	45.12	7.43	43.54	8.77	0.93	< .35
Summary Scales	Mean	(SD)	Mean	(SD)	t - score	p - value
S-1	40.02	6.48	40.39	5.94	- 0.28	< .77
S-2	41.8	7.24	40.34	4.74	1.11	< .26
S-3	40.24	5.84	40.44	6.48	- 0.15	< .87
S-4	46.24	7.24	45.27	6.49	0.66	< .5
S-5	46.9	6.88	46.31	7.57	0.38	< .69
Left Localization Scales	Mean	(SD)	Mean	(SD)	t - score	p - value
L-1	42.32	4.76	41.63	5.8	0.62	< .53
L-2	41.64	5.75	40.17	8.98	0.94	< .34
L-3	47.7	6.6	45.22	10.04	1.41	< .16
L-4	41.0	6.9	40.34	6.5	0.46	< .64
Right Localization Scales	Mean	(SD)	Mean	(SD)	t - score	p - value
L-5	40.16	6.52	40.58	4.46	- 0.35	< .72
L-6	40.64	5.59	40.31	5.69	0.27	< .78
L-7	41.92	6.37	40.54	5.8	1.07	< .28
L-8	43.98	5.57	42.8	8.09	0.81	< .41

Diagnostic criteria for ADHD may include the presence of distractible behavior.

Therefore, the following null hypothesis was examined in this study.

Hypothesis Two:

There will be no significant statistical differences between control and experimental subjects on measures of freedom from distractibility.

Hypothesis two was rejected when the response times of the control and experimental groups to the distractibility task of the GDS were examined.

Table 10

GDS: Distractibility Response Time

Response Time GDS Distractibility			
	Experimental Group (N=50)	Control Group (N=42)	
Mean	45.74	42.59	t = 2.03, p < .04
Standard Deviation	8.03	6.42	
Vairance	64.44	41.2	

Hypothesis two could not be rejected when other aspects of distractibility were measured using the Gordon Diagnostic System (See Table 11).

Table 11

GDS: Distractibility Summary

**Gordon Diagnostic System
Distractibility Task**

	Experimental Group (N=50)		Control Group (N=42)		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Correct	26.4	4.43	25.66	1.16	- 0.64	< .52
Commissions	2.18	7.64	2.15	0.54	0.03	< .98
B-1 Correct	9.24	1.2	9.17	2.1	0.2	< .84
B-1 Om. Er.	0.75	1.2	0.83	2.1	- 0.23	< .82
B-1 Com. Er.	0.63	1.45	0.63	2.11	0	
B-2 Correct	8.65	2.01	8.29	2.47	0.77	< .44
B-2 Om. Er.	1.35	2.01	1.71	2.47	- 0.77	< .44
B-2 Com. Er.	0.67	1.45	0.95	0.95	- 0.65	< .52
B-3 Correct	8.51	2.06	8.2	2.76	0.61	< .54
B-3 Om. Er.	1.5	2.06	1.8	2.76	- 0.59	< .55
B-3 Com. Er.	0.82	1.94	0.56	1.43	0.71	< .48
Commission Errors						
19X	0.14	0.41	0.12	0.33	0.25	< .8
XX9	0.57	2.22	0.27	0.71	0.83	< .41
XX1	0.61	1.64	0.68	1.9	- 0.19	< .85
X1X	0.24	0.63	0.32	0.76	- 0.55	< .58
X9X	0.12	0.33	0.07	0.26	0.78	< .44
XXX	0.43	1.57	0.68	0.68	- 0.53	< .6
Response Latency						
B-1 Time	45.86	9.11	42.19	6.4	2.17	< .03
B-2 Time	45.77	9.04	41.9	10.09	1.92	< .05
B-3 Time	46.40	9.3	43.05	7.59	1.85	< .06
7						
Mean Time	45.74	8.03	42.58	6.42	2.04	< .04

ADHD is reported to be associated with specific cognitive deficits. One of the primary purposes of the LNNB is the diagnosis of general and specific cognitive deficits. Therefore, the following null hypothesis was examined in this study.

Hypothesis Three:

There will be no significant elevations on the Clinical and Localization Scales of the Luria-Nebraska Neuropsychological Battery, (LNNB), Form I, Adult version for individuals with borderline or abnormal scores on the Gordon Diagnostic System.

Elevated scales on the LNNB are those falling above a critical level. Each subjects age and educational levels are used to determine his/her critical level. According to Gordon (personal communication, February 15, 1996) the twenty-fifth percentile may be used to establish borderline scores on the Adult version of the Gordon Diagnostic System.

Abnormal scores would be those beyond two standard deviations from the mean.

Applying those criteria to the control group's performance on the GDS revealed the following:

Table 12

GDS: Vigilance Task Cutoff Scores

	Vigilance Task	
	Borderline Score	Abnormal Score
Correct Responses	< 28	< 27
Commission Errors	> 1	> 2
Response Time	> 55 ms	> 62 ms

Table 13

GDS: Distractibility Task Cutoff Scores

	Distractibility Task	
	Borderline Score	Abnormal Score
Correct Responses	< 19	< 12
Commission Errors	> 8	> 14
Response Time	> 49 ms	> 56 ms

Twenty-seven percent of the control group had at least one borderline or abnormal score on the Gordon Diagnostic System. Seven percent of the control group with borderline or abnormal GDS scores had two or more elevated Luria-Nebraska Neuropsychological Battery scales. The only scale to be elevated for more than one subject was the C-7 Writing Scale. Fifty percent of the experimental group had at least one borderline or abnormal score on the Gordon Diagnostic System (GDS). A difference of proportions test revealed a significant number of subjects in the experimental group achieved borderline or abnormal scores on measures of attention and concentration ($z = -2.23$ $p < .02$). Twenty percent of the experimental group, with abnormal or borderline GDS scores had two or more scales elevated on the LNNB. The C-9 Arithmetic Scale was elevated in one hundred percent of those cases and C-7 Writing Scale was elevated in eighty percent of those cases. An analysis of the data suggests that if individuals struggle with the concepts measured by the GDS (attention, concentration, and distractibility) difficulties with writing and arithmetic are likely. Impairment on the C-7 and C-9 scales are frequently attributed to an individual's learning history (Golden, et al., 1988, pg. 132).

Chapter 5

In the first four chapters of this study the problem was stated, a review of the relevant literature was presented, an explanation of methods and procedures was provided and an analysis of the findings was offered. This chapter summarizes the present investigation, states the findings, provides a trend analysis, draws conclusions, and makes recommendations for future research.

The purpose of this study was to examine and compare neurobehavioral aspects of families with and without members diagnosed as Attention-deficit Hyperactivity Disorder (ADHD). Specifically, answers to the following questions were sought:

- (1) How does the performance of parents who have a child diagnosed as Attention-deficit Hyperactivity Disorder differ from that of similar adults with no family history of ADHD on behavioral, demographic and performance based measures?**
- (2) What identifiable neuropsychological deficits exist for parents with ADHD children as measured by the Luria-Nebraska Neuropsychological Battery?**

Related research, literature and various electronic media were surveyed providing further investigation and understanding into the research questions and to support the theoretical basis for the study. First, the earliest theories of brain-behavior relationships were reviewed and then the location and interactions of Luria's three major units of the brain as related to attention, concentration and distractibility were examined in detail. Research incorporating early versions of the continuous performance measure used in this

study were evaluated and the need for future research regarding attention and concentration was documented. The history of hyperactivity was reviewed along with its hypothesized relationship to brain damage. The selection process for subjects in this study was described and the following research hypotheses were tested at the $p < .05$ level.

Hypothesis One: The performance of biological parents of individuals with Attention-deficit Hyperactivity Disorder will be significantly more impaired than the performance of controls on measures of attention and concentration.

Hypothesis Two: The performance of biological parents of individuals with Attention-deficit Hyperactivity Disorder will be significantly more impaired than the performance of controls on measures of distractibility.

Hypothesis Three: The biological parents of individuals with Attention-deficit Hyperactivity Disorder who achieve borderline or abnormal scores on measures of attention, concentration and distractibility will demonstrate significant elevations on the Luria-Nebraska Neuropsychological Battery (LNNB), Form I, Adult version.

Measures of central tendency were compiled for all collected data that was then subjected to statistical analysis using chi-square tests, t-tests, or difference of proportions tests.

Findings

The performance of biological parents of individuals with ADHD was significantly more delayed ($p < .05$) in the area of response time on tasks measuring sustained attention, concentration, and distractibility. Statistically significant elevations were noted for the biological parents of individuals with ADHD on measures of mathematics and writing.

Findings of this study indicate limited support for the equipotential conceptualization of neuropsychology which postulates that for all human behavior all areas of the brain participate on an equal basis. Such findings are based upon the absence of localized brain injury noted for the experimental group in this study despite their observed and reported behavior disturbances. Also, Luria's functional system approach was only partially supported by the findings of this study in that subjects within the experimental group demonstrated no specific measurable structural deficit but required significantly more time to complete the evaluation tasks.

One possible explanation for this increased temporal request was that individuals with positive ADHD symptoms incorporated Luria's universal second and less efficient, functional system to perform the simple specific tasks related to attention and concentration. This view would support Mirsky's theoretical model dividing attention into a number of separate functions including focusing, executing, sustaining, and shifting. Behaviorally, individuals with positive family history of ADHD struggled with all of Mirsky's functions of attention in a variety of ways.

Experimental group subjects had difficulty focusing on when or where they were to be evaluated. They frequently arrived at the wrong location, day, time, or appointments completely. They had difficulty focusing on instructions which resulted in frequent repetition. Similarly, experimental group subjects displayed considerable difficulty in the execution area negatively affecting the length of time they took to complete the entire evaluation process. Execution also appeared difficult for ADHD subjects because of the amount of extraneous physical and verbal behavior they displayed during the study. It was difficult for the experimental group to sustain their level of response or attention as observed in extended response times recorded during the second of three contiguous time block scores on the vigilance task of the Gordon Diagnostic System. The fatigue observed in experimental subjects might be attributed to their apparent struggles with attention and concentration.

Encoding as a problem for the experimental group was reflected in the processing problems they demonstrated during various evaluation tasks. They frequently made responses that reflected a lack of understanding or a misunderstanding of the presented stimuli. The LNNB allows for some practice responses before a subject's response are scored. The members of the experimental group required more practice time before an acceptable response was obtained.

This study required subjects to make frequent response shifts. While the continual presence of novel tasks may have assisted ADHD subjects in maintaining an acceptable level of attention and focus, many of the subjects in the experimental group continued to

process previous responses that enhanced the difficulties shifting between tasks.

Difficulties in shifting responses were most evident when subjects were asked to respond in a different sensory modality. It would appear that Mirsky's model of attention identified several of the more problematic aspects of attention for members of the experimental group, however, none of the evaluation instruments supported quantitative findings.

In addition to the statistically significant time delays reported for the experimental group, practical time delays were also observed but no statistical analysis was conducted. Frequently subjects with positive ADHD family measures forgot appointment locations or times. Personal communication with Barkley (1993), and Gordon (1996) revealed similar problems when they attempted to schedule appointments for individuals with ADHD. Once the ADHD subjects were in the evaluation room, they routinely took twenty to twenty-five percent longer to complete the process. One speculation for the increased time management problems for individuals with ADHD symptoms may involve the amount of compensation they appear to employ as they responded. Many of these subjects required frequent repetition of instructions and responded with excessive and often complicated responses to what appeared to be simple tasks. Such problem solving skills or adaptations are rarely reported for children in school settings even though considerable research related to attention and concentration problems has been conducted at that level.

Another possible explanation for the lack of statistical significance observed in this study may be related to the nature of the novelty of the evaluation setting. Individuals with ADHD frequently are described as being able to maintain appropriate levels of

concentration and attention in novel or anxiety provoking situations. Most of the participants in this study reported little or no previous exposure to the evaluation tasks. Recent articles as well as personal communication with Barkley (1996) corroborates these hypothetical explanations for the lack of statistical significance. Additionally, current evaluative techniques and instrumentation may not require the subject to focus his or her attention for a sufficient period of time, or to monitor one or two sensory modalities simultaneously.

When the control group in this study was compared with the original normative sample reported in the literature for the Luria-Nebraska Neuropsychological Battery (LNNB), it was observed that this study's control group was significantly less impaired on nine of the eleven original clinical scales ($p < .01$). The two scales not achieving statistical significance were writing and math. One possible explanation for this discrepancy focused on the nature of the sample. The original LNNB sample came from a population that was hospital based while in this study the sample was obtained from the community at large.

While analysis of the data revealed no statistical difference between groups for age, family income or hand preference, the fathers of the subjects in the control group were described as educationally more diversified. Subjects whose family histories were positive for ADHD displayed significantly less education and overrepresentation in traditionally lower paying occupations.

An essential criteria in the diagnosis of ADHD is the early onset of symptoms that are considerably more frequent than those observed in individuals of the same mental age. This is consistent with the findings of this study in which each subject described their

childhood behavior, by responding to traditional behavior checklist items. That is, higher incidences of ADHD symptoms were reported for members of the experimental group with males reporting higher levels of difficulty with learning, immaturity, and frustration. Females reported higher levels of behavioral disturbance in the area of restless feelings.

Trend Analysis

Although statistical significance was not achieved in the measures previously discussed, trends were observed during the data analysis. The mothers of subjects in the experimental group achieved less educationally. Similarly, less education was noted for the subjects in the experimental group. The members of the experimental group displayed more errors to a pattern of responses that included the target sequence plus one non-target number, suggesting that processing visual stimuli and providing a timely motor response may be problematic for individuals with ADHD. This visual processing problem is supported by an analysis of the elevations noted for the experimental group on the visual processing scale of the LNNB.

Practical Significance

All the individuals who achieved borderline or abnormal results were asked to return for a debriefing session. Of those who responded several asked for referrals for further treatment. Before the findings of this study were shared with medical personnel, each subject was asked to complete a psychological screening inventory, a set of current behavioral descriptions, a physical symptom checklist and an extended version of the behavioral check list used in this study. Each subject had his or her spouse and a close

friend complete behavioral checklists and this current information along with the findings of this study was submitted to their physician. Several of these referrals have resulted in significant improvements in the lives of the subjects who took part in this study.

Conclusions

Results of this study indicated that ADHD symptoms appeared to have a negative impact on families and individuals. As reported in the literature related to attention and concentration problems, subjects with positive family histories of ADHD in this study reported high levels of disruptive behavior, demonstrated poor time management skills, achieved less educationally, struggled with writing and arithmetic skills, and possessed delayed response time during tasks requiring sustained attention and concentration. They also demonstrated delayed response times when distracted or subjected to competing stimulus situations.

ADHD evaluation in adults continues to evolve. The instruments used in this study were state of the art at the time this study was conducted, however they did not appear to capture several important aspects of the behavior observed in individuals with positive family histories for ADHD. The use of standardized instruments in this study did provide a mechanism to observe, compare and report some of the more problematic behavior evident in the lives of individuals who struggle with ADHD symptoms.

Recommendations

The conclusions of this study led to the following recommendations:

1. Replication of this study should include lower socio-economic groups and racial diversity in the experimental and control groups at levels proportional to the general population.
2. Evaluation measures with improved diagnostic precision might be incorporated in future research that would provide a greater understanding of the differences in response time, educational levels, and the overrepresentation in lower paying occupations found in this study. Future evaluation instruments might require subjects to respond for longer periods of time and respond to other than visual stimuli.
3. Significant difficulties in mathematics and writing were observed during this study for individuals displaying problems associated with attention, concentration, and distractibility. Future research should be considered to analyze the effectiveness of remediation or pharmacological interventions upon such deficits.
4. Considering ADHD was present in 60 % of the first born children, 29 % of the second born children, and 18 % of the third born children in the experimental group, future research might consider a question regarding the birth order of each participant to further investigate this observation.

5. The effect of the level of severity of ADHD in experimental group families was not controlled for in this study. The existence of co-morbid conditions was not considered in this study except for mental retardation or other gross motor or sensory deficits. Future research might account for such factors in the selection of subject groups.

6. Conversations have been held with experts (Gordon, Barkley, 1996) in the field of ADHD. These experts suggested a research design that would allow for the establishment of three groups. (1) Adults with no family history of ADHD, (2) Adults with a positive family history of ADHD but no current symptoms, (3) Adults with a positive family history of ADHD and current active symptomology. Factor analysis could then be employed to assess the effects of ADHD factors on attention, concentration and distractibility.

7. Considering Dr. Gordon's suggestion that geographic differences might be responsible for the response time differences reported in this study, future studies in different geographic regions of the country are recommended.

APPENDIX 1

Initials: _____ Age: _____ Date: _____ Case #: _____

1. What is the size of your home town?

- A. Rural farm
- B. Small town (10,000 or fewer persons) more than 30 miles from a city of 100,000 or more people.
- C. Small town (10,000 or fewer persons) less than 30 miles from a city of 100,000 or more people.
- D. Middle-sized city (10,000 to 100,00 persons)
- E. Large city (100,000 or more persons)

2. What is your current religious preference?

- A. Baptist
- B. Other Protestant (Congregational, Episcopal, Lutheran, Methodist, Presbyterian, Quaker, etc.)
- C. Jewish
- D. Other Religion
- E. None

3. What are the ages and sex of your children?

#4. Do any of your children have any of the following disabilities?
(If yes please list the age and sex of the child)

- A. Learning disability
- B. Mental retardation
- C. Attention-deficit Hyperactivity Disorder (ADHD)
- D. Emotional problems
- E. Hearing impaired or deaf
- F. Vision problems (other than correctable by eyeglasses)
- G. Speech
- H. Health problems
- I. Other disability not listed (please explain)

5. Do you have any of the following disabilities? Please mark one response for each question on your answer sheet.

- | | | |
|--------------------------------------|----|-----|
| A. Hearing impaired or deaf | No | Yes |
| B. Speech | No | Yes |
| C. Orthopedic | No | Yes |
| D. Learning Disability | No | Yes |
| E. Health-related | No | Yes |
| F. Partially sighted or blind | No | Yes |
| G. Attention-deficit disorder | No | Yes |
| H. Other disability (please explain) | No | Yes |

6. What is the highest level of education achieved by your father (or the male adult who contributed the most to your support while you were growing up)? If no father or male adult was present while you were growing up, please leave blank.

- A. Less than 7 years of school.
- B. Completed junior high school (through 9th grade).
- C. Some high school.
- D. Completed high school degree.
- E. Postsecondary training other than college or community college.
- F. Some college or community college.
- G. Completed 2-year college degree.
- H. Completed 4-year college degree.
- I. Some graduate or professional school.
- J. Completed a graduate or professional degree.

7. What is the highest level of education achieved by your mother (or female adult who contributed the most to your support while you were growing up)? If no mother or female adult was present while you were growing up, please leave blank.

_____ use A. To J. System of question 6 to respond.

8. What is the highest level of education achieved by your spouse?

_____ use A. To J. System of question 6 to respond.

9. What is the highest level of education you have achieved?

_____ use A. To J. System of question 6 to respond.

10. What is your best estimate of your combined total income during the past year?
- A. Less than \$10,000
 - B. \$10,000 to \$14,999
 - C. \$15,000 to \$19,999
 - D. \$20,000 to \$29,999
 - E. \$30,000 to \$39,999
 - F. \$40,000 to \$49,999
 - G. \$50,000 to \$99,999
 - H. Greater than \$100,000
11. Which category best describes your father's occupation (or the occupation of the male adult who contributed the most to your support while you were growing up)? If no father or male adult was present while you were growing up, please leave blank.
- A. High level executive (president or vice-president), major professional (e.g., physician, lawyer, college professor), large business owner, or military commissioned officer (Major or above).
 - B. Business manager (department manager or director), other professional (e.g., accountant, teacher, nurse, engineer), Medium business owner, or military commissioned officer (Lieutenants & Captains).
 - C. Administrative personnel (staff), semiprofessional (e.g., programmer, photographer, reporter), small business owner, skilled office worker, or military staff noncommissioned officer.
 - D. Clerical, sales worker, or technician (e.g., jeweler, computer operator, inspector).
 - E. Skilled manual employee (e.g., carpenter, electrician, farmer, police officer) or military noncommissioned.
 - F. Machine operator, semiskilled employee (e.g., truck driver, longshore worker), maintenance or service worker (e.g., janitor, waiter/waitress, mail carrier, enlisted military).
 - G. Homemaker
 - H. Retired or disabled.
12. Which category best describes your mother's occupation (or the occupation of the female adult who contributed the most to your support while you were growing up)? If no mother or female adult was present while you were growing up, please leave blank.

_____ use A. To H. Categories from question #11.

13. Which category best describes your spouse's occupation?

_____ use A. To H. Categories from question #11.

14. Which category best describes your occupation?

_____ use A. To H. Categories from question #11.

For the remaining questions use the following scale:

- 0 = Not at all
- 1 = Just a little
- 2 = Pretty much
- 3 = Very much

To the best of your recollection, as a child, did others describe you as:

15. Excitable and impulsive: _____

16. Have difficulty with learning: _____

17. Were restless in the "squirmy" sense: _____

18. Restless, always up and on the go: _____

19. Fail to finish things: _____

20. Childish or immature (wanted help you shouldn't need, clinging, requiring constant reassurance): _____

21. Distractibility or attention span a problem: _____

22. Easily frustrated in efforts: _____

23. Mood changes quickly and drastically: _____

24. Denied you made mistakes or blamed others for your mistakes: _____

Consent Form

This consent form is to request your voluntary participation in a study to be conducted in the Fall of 1995 and 1996. Please read the following information and then sign the last section marked "Informed and Voluntary Consent to Participate" if you are willing to participate in the study.

Purpose of the Study

The purpose of the study is to investigate and compare the performance of parents who have children diagnosed with Attention-deficit Hyperactivity Disorder (ADHD) with parents of children with no known ADHD problems on measures of attention, concentration, memory, motor skills and problem solving reading and mathematics.

Amount of Time Involved for Subjects

Subjects will be asked to complete a questionnaire involving biographical information. This will take approximately 15 to 20 minutes. Following that either a test of attention and concentration or a battery of tests involving motor skills, memory and problem solving will be administered. The testing may be completed in 1 hour blocks which will involve a total time commitment of 3 to 4 hours.

Assurance of Confidentiality

All data collected in the study will be kept in confidence. Subjects will be assigned numbers for research analysis and only the investigator will have access to this number. For purposes of analysis only group data will be utilized.

Assurance of Voluntary Participation

Participation in this study is strictly voluntary. The right of the individual to decline to participate or to withdraw at anytime is guaranteed.

Availability of Results

Results of this study may be obtained from the following address:

Michael C. McDonough
C/O Christian Psychotherapy Services
Greenbrier Point, Suite 575
Chesapeake, Virginia 23321

Considering that ADHD is a serious matter, any suspicious results will be reported to participants along with appropriate referral recommendations.

Informed and Voluntary Consent to Participate

I have been informed and agree to participate in the study outlined above. My right to decline to participate or to withdraw at any time has been guaranteed.

VOLUNTEER

DATE

REQUEST

Dear Friends,

I am conducting research as part of the requirement for my Doctor of Education (Ed.D.) degree at the College of William and Mary and I am looking for people to help. The individuals I am looking for must be a married couple with biological children who have no known problems with attention or concentration. I will be evaluating each adult using measures of attention, memory, and motor skills. The total time involvement would be 2 to 3 hours and could be scheduled in 1 hour time blocks or conducted during one session. This research can be scheduled at a location convenient to the participant.

If you know anyone or would be willing yourself to participate, please call my secretary Tammy at 873-0735.

Sincerely,

Michael C. McDonough, Ed.S.

Licensed School Psychologist
Licensed Professional Counselor

Appendix 2

The subjects in this study provided the following historical data.

Table 14

	Experimental Group (N=48)	Control Group (N=42)
Rural Farm or Small Town	38 %	38 %
Middle sized city 10,000 to 100,000 People	29 %	33 %
Large City > 100,000	33 %	42 %

$\chi^2(2, N = 90) = 1.58, p < .99.$

The educational levels of each subject's parents were as follows:

Table 15

SUBJECTS' MOTHERS' EDUCATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=43)
< High School Grad	34 %	23 %
High School Grad	46 %	44 %
Post Secondary Training		
Some College		
2 year College Degree	16 %	19 %
College Grad		
Grad School or Grad degree	4 %	14 %

$\chi^2(3, N = 93) = 8.41, p = < .10.$

Table 16

SUBJECTS' FATHERS' EDUCATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=41)
< 7 years	4 %	20 %
Jr. High or Some High Sch.	32 %	24 %
High School Grad	28 %	20 %
Post Secondary Training		
Some College or		
2 year College Degree	24 %	12 %
College Grad		
Grad School or		
Grad School Degree	12 %	24 %

$\chi^2(4, N = 91) = 24, p < .01.$

When the variable of each subject's parents occupation was considered the following information was gathered.

Table 17

SUBJECTS' MOTHERS' OCCUPATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=43)
High Level Executive Buisness Manager		
Administrative Personnel	12 %	16 %
Clerica, Sales Worker		
Skilled Manuel Employee	18 %	19 %
Machine Operator	16 %	23 %
Homemaker		
Retired or Disabled	54 %	42 %

$\chi^2(3, N = 93) = 1.71, p < .90.$

Table 18

SUBJECTS' FATHERS' OCCUPATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=42)
High Level Executive Buisness Manager		
Administrative Personnel	41 %	36 %
Clerical, Sales Worker		
Skilled Manuel Employee	43 %	43 %
Machine Operator	16 %	21 %

$\chi^2(2, N = 92) = 2.28, p < .90.$

When the current status of each subject was examined the following breakdown was noted.

Table 19

SUBJECTS' CURRENT RELIGIOUS PREFERENCE

	Experimental Group (N=50)	Control Group (N=43)
Baptist	62.5 %	61 %
Other Protestant	37.5 %	39 %

$\chi^2(1, N = 93) = 1.4, p < .90.$

Table 20

SUBJECTS' INCOME LEVEL

	Experimental Group (N=50)	Control Group (N=43)
30,000 or less	16 %	23.5 %
30,000 to 40,000	32 %	25.5 %
40,000 to 50,000	24 %	19.0 %
> 50,000	28 %	33.0 %

$\chi^2(7, N = 93) = 7.73, p < .90.$

Table 21

SUBJECT'S EDUCATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=43)
High School Grad or Less	16 %	16 %
Post Secondary Training		
Some College		
2 year College Degree	48 %	33 %
4 year College Degree	14 %	16 %
Some Grad School	12 %	21 %
Completed Grad School	10 %	14 %

$\chi^2(4, N = 93) = 8.45, p < .10$

In the area of occupations the following data were collected.

Table 22

SUBJECTS' OCCUPATIONAL LEVEL

	Experimental Group (N=50)	Control Group (N=43)
High Level Executive		
Buisness Manager		
Administrative Personnel	50 %	63 %
Clerical, Sales Worker	16 %	14 %
Skilled Manuel		
Machine Operator		
Homemaker	34 %	23 %

$\chi^2(2, N = 93) = 5.72, p < .10.$

Considering Barkley (1993) describes individuals with family histories positive for ADHD as having several behavioral differences a checklist was completed by each participant in this study containing the behavioral descriptors frequently seen as problematic in individuals with attention problems. A study by Boatwright (1995) indicated a retrospective checklist successfully discriminated between groups independently identified as ADHD verses controls with a low percentage of false positives and false negatives for the diagnosis of ADHD.

The behavioral checklist breakdown was as follows:

- 1 = Not at all
- 2 = Just a little
- 3 = Pretty much
- 4 = Very much

For all tables to follow the Experimental Group total N=50 (25 males/25 females), the total N or the Control Group = 44 (22 males/22 females). If significant differences existed for the total group a breakdown by male and female subjects follows:

Table 23

Excitable and impulsive:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	2.0	1.0	1.88	0.90	0.59	< .55

Table 24

Have difficulty with learning:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	1.94	1.0	1.41	0.92	2.6	< .01
Females	1.92	1.08	1.48	0.93	1.46	< .15
Males	1.96	0.93	1.35	0.93	2.17	< .03

Table 25

Were restless in the "squirmy" sense:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	2.3	0.99	1.46	0.71	4.56	< .001
Females	2.0	1.08	1.14	0.36	3.48	< .001
Males	2.6	0.82	1.80	0.83	3.23	< .002

Table 26

Restless, always up and on the go:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	2.4	1.09	1.76	0.99	2.9	< .004
Females	2.1	1.20	1.29	0.56	2.84	< .005
Males	2.6	0.91	2.25	1.12	1.16	< .25

Table 27

Fail to finish things:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	2.16	1.15	1.56	0.71	2.91	< .004
Females	1.96	1.21	1.33	0.48	2.24	< .03
Males	2.36	1.08	1.80	0.83	1.91	< .06

Table 28

Childish or immature (wanted help you shouldn't need, clinging, requiring constant reassurance):

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	1.7	0.91	1.12	0.40	3.78	< .001
Females	1.52	0.82	1.24	0.54	1.33	< .19
Males	1.88	0.97	1.00	0.0	4.04	< .002

Table 29

Distractibility or attention span a problem:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	1.98	1.12	1.44	0.78	2.62	< .01
Females	1.76	1.12	1.44	0.78	1.93	< .06
Males	2.2	1.08	1.65	0.93	1.79	< .07

Table 30

Easily frustrated in efforts:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	2.2	1.03	1.41	0.71	4.17	< .001
Females	2.04	1.06	1.38	0.74	2.40	< .021
Males	2.36	0.99	1.45	0.69	3.47	< .001

Table 31

Mood changes quickly and drastically:

Total Group

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	1.86	1.09	1.49	0.78	1.82	< .07

Table 32

Denied you made mistakes or blamed others for mistakes:

	Experimental Group		Control Group		t - score	p - value
	Mean	(SD)	Mean	(SD)		
Total Group	1.78	0.76	1.49	0.68	1.89	< .06

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