THE UNIVERSITY OF CALGARY

Cognitive Processing in Children with Attention Deficit Disorder, Predominantly Inattentive Type

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF CLINICAL PSYCHOLOGY

CALGARY, ALBERTA

SEPTEMBER, 1998

ABSTRACT

The current study compares populations of children with Attention Deficit Disorder, Predominantly Inattentive Type, Attention Deficit Disorder-Hyperactive/Impulsive Type and Attention Deficit Disorder with co-occuring Reading Learning Disability. Comparisons are made using the Attention and Planning domains of the recently published Das and Naglieri Cognitive Assessment System.

Results indicate similar deficits in Planning for all three diagnostic categories and this suggests that some form of frontal lobe dysfunction underlies Attention Deficit Disorder, Predominantly Attentive type as well as Attention deficit Disorder, Hyperactive/Impulsive type. Results also suggest that children with co-occuring Attention Deficit Disorder and Reading Learning Disability have more severe attentional problems than the other two diagnostic categories.

Results are discussed with regards to theoretical concepts of frontal lobe and attention network function and the relationship of these to the assessment measures used in the present study.

ACKNOWLEDGEMENTS

I would like to extend special thanks to all the young people who participated in this study and to their parents who provided me with so much insight about living with ADD. A special note of thanks, goes out to the staff of the Calgary Learning Centre, Dr. Oakley School and Capitol Hill Elementary School for their help. Additionally, I would like to thank Mrs. Brenda Acheson for her help in contacting many of the subjects in this study. As well I would like to express sincere gratitude to Phyllis Kalmanovitch and Harriet Johnston of the Calgary Roman Catholic Separate School Board for their loan of the Cognitive Assessment System for use in this research.

I wish to thank my supervisor Dr. Marilyn Samuels for her constant encouragement and insight and for her enthusiastic desire to help young people with learning difficulties. Additionally I would like to thank Dr. Anne Price, not only for being on my review committee but for permission to involve the Calgary Learning Center in this project. I would also like to thank Dr. Aldred Neufeldt for his participation and helpful comments at the beginning and conclusion of this project.

Most importantly, I would like to acknowledge the patience and encouragement of my wife Ruth who insisted that I embark on this journey many years ago. I would also like to thank my children, Adam and Amanda, for putting up with a father who was often present in body but not necessarily in spirit. Finally, I would like to acknowledge the generous and practical support of my parents and my wife's parents during my time of study.

Dedication

This thesis is dedicated to the memory of Simona Maaskant, a fellow servant of Jesus Christ who passed away while this study was being conducted.

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Chapter One
Introduction

The human mind is capable of accomplishing a wide variety of tasks which we take for granted in our day to day lives. When examined in isolation, the ability to accomplish these tasks is astonishing when one considers the complex environment in which human's exist and operate. Because of the background noise which exists in any environment in which human beings function there is an obvious requirement to attend only to those cues and stimuli which are important for a specific purpose in a given place and time. This ability is what is frequently termed 'attention'.

The ability to attend to stimuli that are important while at the same time ignoring those that are irrelevant is considered to be one of the most essential human cognitive functions (Matlin, 1994; Das, Naglieri & Kirby, 1994). In addition humans have an apparently unique ability to select a specific stimulus for attention while purposely ignoring other environmental clues. This latter function is an essential capability for structured academic learning. In recent decades attention and attentional difficulties have become a widespread focus of investigation (Matlin). This has been deemed particularly important because of the observed evidence of a connection between attentional problems and difficulties with academic learning (Winzer, 1993).

Since the 1930's researchers and clinicians have observed many children that develop or display persistent symptoms of hyperactivity and impulsivity beginning in the preschool years (Bradley, 1930). In addition, there is a

growing consensus that some children develop difficulties with sustained attention, but without observable hyperactive or impulsive behaviors. Both of these behavioral syndromes tend to become problematic in learning environments (Barkley, 1996). Although attention and its neural correlates are an important avenue of investigation today, historically, research on childhood hyperactivity preceded research on attention and the two behaviors were not connected theoretically until quite recently (Barkley). Thus early researchers were concerned with hyperactivity or hyperkinesis rather than specific abilities or deficits connected with attention (APA, 1968).

In the past two decades a considerable amount of research has been undertaken with regard to the cluster of symptoms that fall under the current DSM-IV (APA, 1994) classification of Attention Deficit Hyperactivity Disorder (ADHD), more commonly known as Attention Deficit Disorder or ADD. This research has been initiated, in part, because of the increasing frequency of diagnosis of ADD within school aged populations. In fact, ADD is one of the most common reasons for referring children for pediatric consultation or psycho-educational evaluation (Stanford & Hynd, 1994). ADD was originally referred to as hyperkinetic reaction of childhood disorder in the DSM- II however the classification was refined to include a category of ADD that presented with inattention but without hyperactivity in the DSM-III (APA, 1968, 1980). A *perceived* lack of clinical and empirical evidence to support a category of ADD without hyperactivity prompted the restructuring of ADD classification in the DSM-IIIR into the hyperactive type as well as a combined type referred to as undifferentiated attention deficit disorder (APA, 1987; Morgan, Hynd,Riccio & Hall, 1996; Stewart, 1994).

It was apparent, however, that the dismissal of ADD-without hyperactivity was premature as evidence accumulated that such a symptom cluster existed. In an attempt to reduce confusion caused by the unnecessarily heterogeneous classification system in the DSM- IIIR, the DSM-IV once again divided this disorder into a Combined Type that includes symptoms of impulsivity/hyperactivity and inattention, a Predominantly Inattentive Type and a Hyperactive/Impulsive subtype (APA, 1994; Stanford & Hynd, 1994).

Controversy exists over whether or not the DSM-IV categories actually represent the true clinical picture of ADD (Barkley, 1996; Stewart, 1994). As noted above, the DSM-IV describes the existence of a sub-type described as ADHD-Combined Type which includes symptoms of hyperactivity, impulsivity and inattention (Morgan et. al., 1996). Although this symptom cluster is included as a diagnostic category, recent studies involving factor analysis have supported the existence of only two basic sub types of ADHD (Barkley et. al., 1996; Lahey et. al., 1990). These studies made use of comparisons based on the original DSM-III criteria along with other factors believed to be associated with ADD without hyperactivity (called ADD W/O in the DSM-III). The studies were in general agreement as to factors underlying ADD: the first involving behaviors of hyperactivity/impulsivity associated with ADHD- Hyperactive Type and the second involving symptoms of inattention and disorganization associated with ADD- Without Hyperactivity (Lahey & Carlson, 1991).

The DSM -IV makes use of the general category title of Attention Deficit Hyperactivity Disorder or ADHD and then adds a qualifier which identifies sub-type for diagnostic purposes (APA, 1994). This terminology is

unnecessarily confusing and thus, for the purpose of this study, the term Attention Deficit Disorder (ADD) will be used to describe the general syndrome. The symptom cluster which excludes hyperactive behaviors will be referred to as Attention Deficit Disorder, Predominantly Inattentive Type or ADD PI. The type which includes hyperactivity/impulsivity will be referred to as Attention Deficit Disorder-Hyperactive/Impulsive Type or ADD H+. When referring to or quoting from the work of other researchers in this area, the above abbreviations will be used to describe Attention Deficit Disorder with clarification added in parenthesis, if required.

The current study is partially based on recent research that has examined not only the behaviors but also, the neural correlates of attention. As a result of these efforts considerable evidence has been uncovered for the existence of at least two task dependent attention networks within the human brain (Rothbart , Posner and Hershey, 1995). This evidence, combined with an examination of how stimulant medication works to alleviate attentional deficiencies, has allowed the emergence of a theoretical picture of what is happening to create the difficulties seen in children and adults with Attention Deficit Disorder (ADD). Along with the foregoing, examinations of behaviors resulting from site specific brain injury have uncovered parallels between these behaviors and those associated with ADD. This has provided us with evidence that deficiencies in the function of the frontal lobes of the human brain may be responsible for the secondary features associated with this disorder.

In spite of the various revelations from current ADD research there are a number of issues that remain unresolved. The first is that of the subjective

interpretation of attentional behaviors. Individuals who are skeptical of current widespread levels of ADD diagnosis point to the fact that some inattention is a behavioral trait of almost all school aged children. In connection with this objection is the observation that all children, whether they have been diagnosed with ADD or not, seem to be able to attend to some limited types of stimuli or to participate intensely in activities that interest them most. In connection with the foregoing, there is the problem of understanding how emotion and emotional regulation is associated with attention. An additional issue, and one that this study is designed to address, is whether or not children with significant problems with inattention, have similar cognitive abilities and deficits as those individuals who experience problems with hyperactivity and impulse control.

At the present time, evidence exists for the distinctiveness of ADD-Predominantly Inattentive Type as compared to ADD Hyperactive/Impulsive Type based on external behaviors and associated syndromes. However, the challenge that remains is to provide external validation of ADD-Predominantly Inattentive Type. Two points of view served to provide initial direction for the current study. The first is contained in a recent review by Stewart (1994), wherein it is noted that current evidence used to distinguish the two sub-types of ADD depends to a large extent on behavioral measures and that it is these same behavioral measures that were used to make the initial diagnosis. That this is a rather circular approach is indicated by Barkley, DuPaul and McMurray (1991), when they state that " Such confounding of both the source and the type of independent and dependent measures ensures that the study will find differences between the two groups

" (p.520). Stewart states that external validation must be based on measures that are independent of those used to initially formulate the groups or in this case make the initial diagnosis of sub-type. The second viewpoint is that expressed by Barkley (1996; Barkley, DuPaul, McMurray, 1991) that ADD-Hyperactive/Impulsive Type and ADD -Predominantly Inattentive Type may be distinct clinical and etiological entities. It should be noted that Stewart does not dismiss the possibility that Barkley et. al. may be correct but that, at the present time, external validation of ADD Predominantly Inattentive type has not been established based on the criteria that he describes.

Measures that have been used in attempts to externally validate ADD PI in past research include: a) the differences between the two sub-types with regard to their comorbidity with various psychological disorders, b) differences of response of the two ADD sub types to varying dosage levels of methylphenidate and c) differential results of individual cognitive and achievement testing based on ADD sub-type (Barkley, Grodzinsky & DuPaul, 1992; Stewart, 1994). None of these examinations have settled the question of the relationship between ADD-Hyperactive/Impulsive Type and ADD Predominantly Inattentive Type. Part of the reason for this failure is that few of these measures have been tied through research and theory into a coherent model which describes how specific neural deficit might lead to the distinct behavioral spectrums associated with ADD. A second difficulty is that in spite of more recent recognition of the two forms of ADD as distinct symptom clusters, the bulk of research from the last three decades has confined itself to the hyperactive/impulsive form of ADD or else has made use of heterogeneous groups of children with ADD who have not been

classified based on sub-type. Finally, past research has made use of heterogeneous groups of children with ADD who have often not been screened for comorbid Learning Disability.

Investigation of the functions of various brain structures conducted by Luria and others during the nineteen fifties and sixties has provided us with a broad conceptual framework which has served to integrate more recent discoveries with regard to human neural functioning (Luria, 1973). As described above, the cognitive/neural processing domains that are most likely related to ADD are the frontal lobes and the attentional networks. In addition, however, the observed relationship of Learning Disability to attentional problems and ADD in particular, signifies that modern research into encoding and decoding of information may also be relevant (Nieves, 1991).

In an attempt to combine the conceptual work of Luria along with more modern investigations, Das, Naglieri and Kirby (1994) have integrated evidence from a number of fields into a theoretical framework of human cognitive function. This framework is referred to as the P.A.S.S. theory of intelligence. These authors have concluded that human cognitive functioning is best understood as being divisible into the functional domains of planning and attention along with successive and simultaneous processing of information. According to this, and following from Luria (1973, 1980), planning is associated with executive and therefore frontal lobe function. Attention is related to the action of key centers in the brain stem on higher cortical functions. Successive and simultaneous processing refer to the two modalities by which information from the senses is received, processed, memorized and retrieved (Das & Naglieri, 1994).

Investigations of the types of everyday tasks that might relate to the four functional areas of the P.A.S.S. theory has spanned more than two decades. Factor analytic studies, for example, have provided significant confirmation that these functional areas are a defensible and reasonable framework for understanding human cognitive function (Naglieri, Das, Stevens & Ledbetter, 1991; Naglieri, Prewett & Bardos, 1989). As a result of these extensive investigations, the P.A.S.S. theory has been recently incorporated into a cognitive battery of tests now known as the Cognitive Assessment System or C.A.S. (Das & Naglieri, 1997). The C.A.S. is unique in being the first multiple domain cognitive measure that is based on an extensive theoretical foundation from its very inception.

The four domains that are examined by the C.A.S. are widely recognized as essential functional areas of human cognition and at least two of these, planning and attention, are related to Attention Deficit Disorder. Based on this recognition, it is likely that the such an assessment tool may highlight cognitive processing differences between ADD Hyperactive/Impulsive type and ADD Predominantly Inattentive type if such exist and are measurable. In addition, the C.A.S., based as it is on neurological research and theory and not on behavioral observation, also fulfills the requirement of a measure which may be used in evaluating the external validity of ADD predominantly inattentive type.

The current study was motivated not only by controversies over classification and diagnosis of ADD but also by a lack of understanding of how attention deficits and learning disabilities are associated. As noted earlier, there is a strong association between ADD and learning disability and, in fact,

there is considerable co-occurence of the two (Barkley, 1996). In the light of this it is very important that research efforts undertake a thorough investigation of ADD sub types and their similarities and differences with regard to underlying neural processes. The current level of understanding of these two classification is insufficient both theoretically and practically and this has not only led to confusion in the literature but difficulties in assessment as well (Morgan et. al, 1996). Additionally, research must begin to target neural correlates of cognitive processes in both ADD and LD to discover if these disorders are indeed distinct, as researchers such as Lyon (1996) suggest, or whether or not a continuum of related neural deficits exists upon which learning disabilities and attentional problems can be placed. It is felt that research which targets the cognitive processing of children classified as either subtype of ADD and those with comorbid ADD and Learning Disability would be an appropriate place to begin such an investigation.

The current study examines three groups of children previously diagnosed as ADD PI, ADD H+ or ADD with comorbid Reading Learning Disability using the Planning and Attention Domains of the Das and Naglieri Cognitive Assessment System (1997). The analysis is designed to determine whether or not these groups can be distinguished on the Planning and Attention domains based on tests of statistical significance. The results provide information with regard to similarities or differences in frontal lobe and attentional functioning between the three diagnostic groups.

Chapter Two

Literature Review

The DSM-IV as well as the most recent research literature describe Attention Deficit Disorder in terms of three domains. The first is that of observable problems with inattention, sustained attention and distractibility. A second domain might be described as associated behaviors and these include deficits in impulse control, overactivity and planning or organizational ability. A third domain, not included among primary diagnostic symptoms is that of associated features which include comorbid disorders, oppositional behaviors, peer and learning problems (APA, 1994). Research into all three of these domains has some bearing, not only on diagnosis, but also on the ability to understand and distinguish between the two basic types of ADD. However, as will be shown, only those lines of research that provide a connection with some plausible theory of etiology will assist in providing the external validity of ADD PI that is required in order to consider it to be distinct from ADD H+. These investigations are those that employ measures of cognitive processes that are correlated with known areas of human neural functioning. As will be seen, the list of potential lines of investigation that would provide the necessary evidence are limited and are associated only with the first two diagnostic criteria described above.

Attentional Networks and Research on ADD

The most recent and well established theory of the function of attention and its neural correlates has been put forward by Rothbart, Posner and

Hershey (1995). These researchers first describe evidence for the two specific but interconnected attention networks: (1) the Posterior Attention Network (PAN) which involves areas of the parietal cortex as well as parts of the thalamus (both implicated in motor and sensory behavior) and which orients our attention to sensory stimuli and (2) the Anterior Attention Network (AAN), which involves parts of the lateral frontal cortex and the frontal caudate nucleus and which is active during target detection involving visual color, form or semantic association. A third system, termed the Vigilance Network, involves Norepinephrine (NE) input from the locus ceruleus into the frontal cortex. It is important in maintaining the alert state and the authors partly associate it with the deficits seen in ADHD. There appears to be such a close association between vigilance and the function of the PAN and AAN that the Vigilance Network is not described separately in much of the research literature on attention.

Although an association between ADD sub-type and the function of a specific attentional network is not suggested by Rothbart, Posner and Hershey (1995), other researchers have conjectured about which network may be implicated in either ADD PI or ADD H+ symptoms. Barkley, Grodzinsky and DuPaul (1992), for example, have suggested that there is evidence that children with ADD PI may have differences in focused attention while those with ADD H+ experience problems with sustained attention and that these are correlated with the the attention networks described in modern research (Lahey & Carlson, 1991). In an article published in 1991, Barkley, Du Paul and Mc Murray appear to have the PAN and AAN in mind in their discussion which describe the response of the two sub-types of ADD to various dosages

of the stimulant medication methylphenidate. First, they provide evidence that sustained attention and vigilance are associated primarily with ADD H+ and that this is connected with function in the anterior prefrontal lobes. They further suggest that focused attention is a significant problem in children with ADD PI (-H in their article) and that this is associated with parietal/temporal substrates of the brain.

The article by Barkley DuPaul and Mc Murray (1991) describes research in which both sub-types of ADD were found to be responsive to methylphenidate therapy. However, additional findings were that children with ADD PI were less likely to respond, or to respond to lower doses of methylphenidate than children with ADD H+. Thus, although some differences between the two ADD sub-types were uncovered based on response to methylphenidate, a specific conclusion with respect to where these differences might lie in terms of neural functioning was not offered.

A further clarification of theoretical issues surrounding the effect of stimulant medication on attentional networks is provided by Pliszka, Mc-Cracken and Maas (1996). In a thorough review of the current level of understanding of neural correlates of ADD, the authors provide evidence that stimulant medications have the effect of enhancing a smooth hand-off between the Posterior and Anterior attention networks. They suggest that the Locus Ceruleus, a center in the brain stem with rich connections to higher cortical centers, is operating at too high a level in individuals with ADD and thus does not facilitate a smooth "hand off" from the PAN (which focuses attention on a specific stimulus) to the AAN (which is the network designed

to provide vigilance and sustained attention). Stimulant medication, which is designed to imitate the effects of Norepinephrine (NE) in the brain, actually resets the Locus Ceruleus to a lower level so that it can effectively manage the hand off from the PAN to the AAN. The description provided by Plizska, McCracken and Maas also indicates that, stimulants affect both the function of PAN and AAN and that the function of these is closely related. Based on their description of the role of NE in the PAN and AAN, research into stimulant/NE function is unlikely to provide substantial information about quantifiable differences between ADD H+ and ADD PI.

Before leaving the subject of attentional networks, it should be noted that there are other differences between the function of the AAN and PAN. Specifically, the function of the AAN is modulated not only by the noradrenergic (involved in the production of Norepinephrine) systems but also, the dopaminergic systems. By contrast the PAN is influenced primarily by the noradrenergic system (Pliszka, McCracken & Maas, 1996). Additionally, NE suppresses the spontaneous activity of the prefrontal cortex but enhances its response to specific input and allows enhanced mental manipulation of specific information. The role of NE in the PAN is to enhance the individuals response to novel stimuli (Rothbart,Posner & Hershey, 1995).

When we compare the most commonly reported behavioral presentation of ADD PI children with those with ADD H+, an additional difficulty with distinguishing them based on specific attention network dysfunction is identified. If it is true, for example, that ADD H+ children have trouble inhibiting their response to novel stimuli we might ask if this is truly AAN dysfunction or if on the other hand, it indicates over function of the

PAN as indicated in the model described above by Pliszka et. al.(1996)? Conversely, if ADD PI children have a deficit in focused attention, does this indicate a deficit in the function of the PAN or over engagement of the AAN? The evidence described previously suggests some differences between ADD PI and ADD H+ based on deficits in specific types of attention. However, as stated above, the close connection in function between the two attentional systems as described by Pliszka, McCracken and Maas (1996) indicates that it is likely an over simplification to suggest that each sub type of ADD can be tied specifically to an exclusive dysfunction in one or the other attentional networks.

ADD- Associated Features and Frontal Lobe Dysfunction

Additional factors which appear to distinguish ADD PI from ADD H+ include behaviors and comorbid syndromes which are most often associated with each subtype. ADD H+ is associated with levels of impulsivity and hyperactivity which are considered to be inappropriate for a child's age (Chelune et. al., 1986). Additional social/emotional factors connected with ADD H+ include the development of oppositional and defiant behaviors as well as increased likelihood of alcohol or substance abuse (Aust, 1994) . By contrast, ADD PI tends to be associated with inattention, forgetfulness and sluggish tempo as well as increased risk for internalizing behaviors that lead to anxiety disorders and depression (Barkley, 1996; Lahey & Carlson, 1991).

Indirect evidence of differences in neural functioning in ADD comes from the noted parallels between behaviors of these individuals and patients

who have received lesions or other insult to the frontal lobes of the cerebral cortex (Chelune, Ferguson, Koon & Dickey, 1986). Numerous lines of research have implicated the frontal lobes of the human cerebral cortex in what are termed executive brain functions (Barkley, 1996; Kalat, 1995; Luria, 1980). Executive functions are more readily described as those pertaining to focused attention, willful behaviors and planning. Behaviors observed following frontal lobe damage include being in a reduced state of activity, being easily distracted by irrelevant stimuli and difficulty with planning (Luria, 1980). This has led to theories of frontal lobe deficit as the basic underlying cause of ADD H+ but not necessarily ADD PI (Barkley, 1996; Chelune et al.,1986, Fuster, 1989).

The most elaborate model that associates the behaviors of ADD H+ children with frontal lobe dysfunction is that described by Barkley (1996). Based on a number of lines of earlier research, Barkley implicates deficits in executive functions of the brain in generating the basic symptoms seen ADD H+. Barkley's model places a breakdown in what is described as behavioral inhibition at the center point in relation to four other executive functions. These four include: prolongation/working memory, self regulation of affect, internalization of speech and reconstitution. The term "reconstitution" describes an inability to take apart the verbal representations of objects and actions as a way of delaying and contemplating a response to complex stimuli. Deficits in these four executive areas are believed to account for behaviors in ADHD such as: inability to inhibit prepotent responses, delayed development of self talk and moral restraint, reduced ability to prolong mental representations and long term goals and reduced emotional self control. As

Barkley states however, this model likely applies to ADD H+ only and not to ADD PI.

The recognition that frontal lobe dysfunction may underlie the behavioral and cognitive representations of those with ADD H+ has led to two distinct lines of research to verify this theory. The first involves attempts at observing differences in frontal lobe functioning of the brains of children with ADD. The second involves an attempt to find differences based on cognitive tests of presumed frontal lobe functions.

A study by Lou, Henriksen, Bruhn, Borner and Nielsen (1989) involved a group of ADD children(no sub-types indicated) aged six to eleven years. Positron Emission Tomography (PET) scans revealed hypofusion and theorized hypofunction in the striatum that lies at the head of the caudate nucleus of the brain. The authors state that lesions made in this same area in laboratory animals produce behaviors that include hyperactivity and attention deficit along with poor performance on delayed reaction tasks. A study using similar methodology by Zametkin, Liebenaur et al. (1993) involved adolescent boys but uncovered no significant differences in brain glucose metabolism in ADD subjects. Notably, a previous study by Zametkin, Nordahl et. al. (1990) showed lowered glucose metabolism in premotor and superior prefrontal cortices of adults who had been diagnosed with ADD in childhood.

A number of studies of the role of frontal lobe dysfunction in ADD have made use of measures of associated cognitive function to establish possible deficits in ADD children. The study by Chelune et. al. (1986) involved measures of cognitive flexibility and sequential processing as well as the

Wisconsin Card Sorting Test (WCST). Consistent differences between ADD children and controls were found on the WCST which is considered to be a measure of frontal lobe function (McCrea, 1998). A 1992 study by Shue and Douglas uncovered differences between children with ADD and controls on tasks sensitive to frontal lobe function but not on those sensitive to temporal lobe dysfunction. Frontal lobe tasks found to differentiate subjects included the Go-No Go task which is designed to measure inhibition, the Conflicting Motor Response test which compares response to verbal instruction and direct modeling, conditional discrimination tasks and Trail Making Tests.

A comprehensive review of contemporary research into ADD that make use of measures of frontal lobe function was provided in the introduction to a study by Barkley, Grodzinsky and Du Paul (1992). These researchers were concerned not only with distinguishing ADD individuals from normals but additionally, whether or not measures of frontal lobe function are capable of distinguishing ADD H+ from ADD PI. In this instance two groups of non-ADD children, with and without Learning Disability were used for comparison and control. The authors uncovered significant differences in performance between subjects with and without ADD on the Continuous Performance Test (CPT) and the Stroop Interference Test. The Stroop test was also able to distinguish between normal children and those with learning disability but without comorbid ADD. The authors did not find differences based on the Pegboard, Hand Movements, Porteus Mazes, Rey Osterrieth, Trail Making or WCST tests. In addition, no clear pattern was established which would distinguish between ADD H+ or ADD PI children based on measures of frontal lobe functioning.

Barkley et al. (1992) point out sources of methodological problems with previous ADD- frontal lobe studies, some of which had more positive findings than their own research. The deficiencies they describe include using heterogeneous mixtures of ADD H+ and ADD PI individuals, not confining the subjects to more discrete age categories (e.g. mixing children and adolescents) and failing to control for significant learning disabilities within subject populations. Additionally, many of the so called frontal lobe measures used in previous research are drawn from adult literature and are not necessarily valid measures of similar neural functioning in children. They rightly conclude that any investigation which proposes to examine the etiology of ADD must take these factors into account.

In the current study, an awareness of the limitations of previous research has guided the methodology. In particular, the challenge to examine the association between attentional problems and learning difficulties was prominent and mandated the inclusion of LD children. However the current level of understanding of Learning Disability makes establishing criteria somewhat arbitrary. Recent research has, however provided a basis for investigation of cognitive processes involved with both learning and attention.

Co-occurence of ADD and Learning Disability

The overlap between attentional behaviors and learning disabilities (LD) is one of the more significant sources of controversy in this field. In fact, an examination of the landmark works on Learning Disability such as that edited

by Obrzut and Hynd (1991) shows that inattention is the most frequently discussed behavior in connection with LD. Additionally Barkley states that "The vast majority of clinic referred children with ADHD have difficulties with school performance, most often underproductivity of their work." (1996, p.90). Barkley further suggests that up to 40% of ADD (called ADHD in his summary) children have received special educational assistance of some form or another.

Note that although children with ADD often have learning problems this does not mean that they have a specific Learning Disability. In fact only 19 to 26% (depending on the diagnostic criterion used) of children with ADD have co-occuring Learning Disability (Barkley, 1996). These statistics along with the fact that the cognitive processing deficits in ADD and LD appear to be quite different has led Lyon (1996) to conclude that these are, in fact, distinct types of disorders. Unfortunately, the types of criteria that are most widely used in Learning Disability diagnosis do not necessarily provide a great deal of data that aids our understanding of cognitive processing differences between LD and ADD.

The ability/achievement discrepancy model is a widely used method of diagnosing LD and is based on the concept that Learning Disability is best identified by a child's achievement in a certain area (such as reading) being significantly below expectation. Expectations are based on results of the child's performance on intelligence tests as well as on level of education. This model is used in the DSM-IV (APA, 1994) diagnostic criteria for Learning Disorders but has recently come under considerable criticism (Morrison & Siegal, 1991). Morrison and Siegal base part of their criticism on the fact that

conventional IQ testing does not measure problem solving skills and more specifically, that IQ scores do not predict *cognitive processing* required for reading spelling, language or memory (emphasis mine).

The importance of using underlying cognitive processing differences as a method of distinguishing learning disabilities has been emphasized in recent research (Fletcher et. al. 1993 ; Swanson, 1993). An extensive review of the most current literature shows that historically, the definition of LD has been a persistent problem (Doris, 1993; Wong, 1996). As Wong emphatically puts it "Achieving a consensus on its definition among all those in the field may amount to a miracle" (p. 26). She suggests that a solution to the problem would involve an explanation and a way to operationalize the underlying *processes* involved in learning disability. Note that the area of contention is not the existence of learning disabilities within different modalities such as reading and writing. Additionally, recent research has targeted suspected areas of brain processing dysfunction in learning disabilities. However, there appears to be some controversy as to whether or not older and more widely used methods of diagnosing learning disabilities are measuring cognitive processes that are necessary for the specific learning modalities (Lyon 1996).

As regards the definition and diagnosis of learning disabilities, there is a considerable gap between current practice and methods that might be based on recent findings (Lyon, 1996; Morrison & Siegal, 1991). A practical solution is offered by Morrison and Siegel who along with a number of LD researchers recognize that, as far as Reading Disability is concerned, the core deficit appears to be problems in phonological processing (Manis, 1996; Stanovich, 1994).

Factors other than decoding and recognizing words are involved in reading. However, a deficit in these areas is foundational to learning disabilities, particularly in early elementary aged children. Additionally, Morrison and Siegal state that "when a difficulty with phonics and/or word recognition is used as the basis of the definition of a reading problem, then disabled readers appear to have reasonably homogeneous cognitive profiles . . ." (1991, p. 91). A reasonable conclusion based on recent findings is that recognition of a Reading Learning Disability is best accomplished using measures that are sensitive to phonological processing and word recognition abilities.

Research Involving Learning Disability and ADD

An attempt to investigate the ability of various measures to distinguish between ADD and LD children was undertaken by Kuehne, Kehle and Mc-Mahon (1987). This research used subjects who: 1) met behavioral criteria for ADD with learning problems but not LD, 2) met criteria for LD but not ADD and 3) a control group that did not meet criteria for LD or ADD. The authors state that the Conners Parent Questionnaire, Conners Teacher Questionnaire, Matching Familiar Figures Test and Porteus Mazes distinguished between these groups. This conclusion was based on significant levels of congruity being attained in comparisons between specific measures and previous diagnosis using DSM-III criteria. This study is interesting in that the two latter measures, claimed to have discriminatory power, are not behavioral measures. However, the authors do not link the abilities that these instruments measure to any theory of underlying neural or cognitive

processing and claim that in fact, these instruments are measuring attention span, impulsivity and overactivity. In addition, no distinction was made with regard to the sub-types of ADD being examined.

More recent research has been targeting behavioral similarities and differences between ADD PI, ADD H+ and Learning Disability. A recent study by Stanford and Hynd (1994) supports the concept that the overall behavioral profile of ADD PI (referred to as ADD W/O in their study) is somewhat similar to that of learning disabled children. However, the research did indicate some behavioral features that were unique to both ADD PI and ADD H+ as opposed to the group with LD. In particular, children with ADD PI appear to be able to change strategies to meet specific task demands, however, they were found to have deficiencies in timed perceptual motor tasks. Children with ADD H+ were less able to change strategies to meet task demands. Additionally, they had no deficits in timed perceptual motor tasks but did exhibit impulsive responding. This study made use of groups of children who displayed behaviors indicative of ADD PI and ADD H+ as well as a group with undifferentiated LD. Although unique in exploring the ADD /LD relationship this study primarily explored *behavioral* distinctives of ADD H+ and ADD PI and thus suffers from the limitations stated above.

As indicated by the foregoing, research into the etiology, identification and diagnosis of Attention Deficit Disorder and Learning Disability has been hampered not only by an over reliance on behavioral measures but additionally by the lack of a coherent theoretical approach that would tie existing cognitive measures together. These factors have also hindered attempts to understand the origin of relative strengths and deficits in clients

who present with comorbid attentional and learning problems.

Origins of the P.A.S.S. Cognitive Processing Model

Among the researchers who, in the 1970's, were dissatisfied with contemporary attempts to assess and understand processes involved in reading and language skills were Das, Kirby and Jarman (1979). These authors, along with their associates have described a model which yields measures that can be theoretically linked to what are termed *simultaneous* and *successive* processing in language and reading. Kirby and Robinson (1987) summarize this model as follows:

> The concept of simultaneous and successive processing originated in Luria's clinical examinations of persons with cortical lesions (Luria, 1966a, 1966b). Simultaneous processing refers to the synthesis of separate elements of information into a holistic, unitary representation, in which any portion of the synthesis is immediately surveyable without dependence upon its position in the whole. . . Successive processing refers to the synthesis of separate elements of information into a sequential, temporally dependent ordering. (p.243)

These authors state that measures of simultaneous processing include tasks of "spatial ability, in which a figure composed of distinct parts must be processed as a whole entity and language and reading tasks, in which the semantic relationships among separate linguistic elements must be identified" (p.243). Measures of successive processing are said to include "sequential memory tasks, the production of or comprehension of syntactic structures in language,

and the analysis of sequences of sound in a word (decoding)" (p. 243).

Subsequent investigations revealed that not only can simultaneous and successive process be operationalized but that this is possible in all educational levels from elementary through college (Kirby & Das, 1978; McCallum & Merritt, 1983; Naglieri & Das, 1987). Simultaneous and successive processes have also been found to be a universal human cognitive process. Research has identified this type of processing in various ethnic groups such as North American Native, Chinese, Australian, East Indian as well as in Canadian, U.S.and Australian populations (Naglieri, Prewett & Bardos, 1989). Additionally, this processing has been identified in exceptional children and adults including learning disabled and gifted populations (Kirby & Robinson, 1987; Karnes & Mc Callum, 1983). Finally, research has uncovered substantial evidence that simultaneous and successive processes are related to achievement in reading (Kirby & Robinson, 1987) and that these processes correlate significantly with measures of reading decoding (Das & Cummins, 1982).

Following the operationalization of successive and simultaneous processing, which encompasses the second functional unit in Luria's model, operationalization of Luria's third unit, planning, was undertaken by Das (1980, 1984), Das and Dash(1983) and Das and Heemsbergen (1983). As described previously, planning is associated with the activities of the frontal lobes of the brain and involves highly complex executive type functions. Another way of summarizing this is that the prefrontal cortex is primarily responsible for cognitions and behaviors associated with an internal representation of the world (Goldman-Rakie, 1988). Activities associated with

this function includes regulation and verification of activity, planning and inspection of progress, solving problems and general self monitoring (Naglieri, Prewett & Bardos, 1989). Many of these activities are those affected by dysfunction in inhibitory control as outlined in Barkley's 1996 causal model of ADD H+ described previously.

Recent investigations have shown that planning arises as a unique construct in factor analytic studies and that additionally it can be efficiently operationalized (Naglieri, Das, Stevens & Ledbetter, 1991). Simple tasks that have loaded on planning include trail making, the Wisconsin Card Sort and a task that involves a search for two like numbers in a row of six. Additionally, research has demonstrated that planning is different from and more than speed of processing even though it has often been measured using timed tests (Naglieri, et. al., 1991).

The first of Luria's three functional areas, that of attention, was the last to be operationalized and included in the P.A.S.S. theory by Naglieri et. al. (1991, 1994). As noted previously, attention has been measured using a variety of tasks in the past. As also described, recent research has indicated that behaviors associated with attention arise primarily, through the action of two interrelated networks (Posner & Petersen, 1990; Rothbart Posner & Hershey, 1995). The posterior attention network functions to orientate the individual to a point in space and is important in selective attention tasks. The anterior attentional system is active during visual target detection and is sensitive to conflict blocks (Rothbart, Posner & Hershey). Das, Naglieri and Kirby (1994) have recognized the role and function of these attentional networks in research aimed at operationalizing attention as a factor in the P.A.S.S. model.

Tasks that have been found to load on attention include the Stroop interference test (Golden, 1978) as well as those that involve selective letter and number searches (Das & Naglieri, 1997).

Operationalization of the four factors in the Luria-Das model has involved research that has spanned more than two decades. The result has been the publication, in 1997 of the Das and Naglieri Cognitive Assessment System or C.A.S. The C.A.S. is comprised of subtests which are divided into the four functional areas: planning, attention, simultaneous and successive processing, as described above (Das, Naglieri & Kirby, 1994). Each of the four functional areas are tested using two subtests each, with these eight tests comprising the basic battery. An optional subtest can be added to each of the four functional areas for a total of twelve tests which comprises the standard battery.

Research Using P.A.S.S. Theory

Some recent studies have examined children with Learning Disability and Attention Deficit Disorder using the P.A.S.S. theory. Some of these studies made use of tests that were similar to, but not necessarily identical with, the tests in the recently published form of the Das and Naglieri Cognitive Assessment System (1997).

A study by Kirby and Robinson (1987) concluded that "reading disabled children employ simultaneous processing in the early stage of reading for both word recognition and syntactic analysis, tasks which are more appropriately handled with successive processing" (p.250). In another study,

Reardon and Naglieri (1992) examined P.A.S.S. processing differences between male children with ADD (according to DSM -III criteria, sub-type not indicated) and those without ADD in a regular classroom setting. The results showed that the ADD males earned consistently lower scores in all areas. Using multivariate analysis the authors discovered that the ADD population displayed significantly lower functioning in attention, planning and successive areas with the lowest occurring in the area of attention. The groups did not differ significantly in simultaneous processing. Note that in studies where the experimental ADD group is not specified according to sub-type it is most likely that they are predominantly H+ since this group forms roughly 85% of all diagnosed ADD cases (Barkley, 1996).

A thesis study undertaken by Drummond (1997) used a prototype of the Das and Naglieri Cognitive Assessment System (1997) to compare differences in cognitive processing between gifted and average children with or without severe decoding difficulties. The author did not examine children with ADD. The results of this study indicated that children with reading decoding disabilities show a significant reduction in the area of successive processing as compared to their fellow students who do not have reading LD regardless of classification as either gifted or average in terms of IQ and achievement.

In the interpretive handbook which accompanies the published version of the Cognitive Assessment System (1997), Das and Naglieri describe further research involving special populations including children with learning disability and those with Attention Deficit Disorder. Generally, these studies support prior research using the P.A.S.S. theory. Children with LD, for example, were found to have better scores in simultaneous as compared to

successive processing which concurs with the result found by Das and Kirby (1987). Studies using heterogeneous mixtures of children with both ADD sub-types indicated reduced attention scores with the lowest scores appearing in the area of planning. These results were somewhat different than those obtained in the Reardon and Naglieri study (1992). As described above, in the Reardon And Naglieri study, attention scores were lowest and scores were reduced in the areas of planning and successive processing.

The existing research involving the P.A.S.S. theory has examined questions which have bearing on the current study. However, to date, in research in which P.A.S.S. theory has been used as a basis for examining Attention Deficit Disorder the question of ADD sub-type or comorbidity with Learning Disorder has not been addressed.

Summary

A considerable body of evidence points to deficits in the function of frontal lobe activities as a causal explanation of behaviors associated with ADD H+. In addition, behaviors associated with both ADD H+ and ADD PI have been linked to overall dysfunction in the two identifiable attention networks of the brain. From this it is concluded that any investigation of similarities or differences between ADD PI and ADD H+ should be comparing these disorders using well validated measures of frontal lobe and attention functioning.

In addition to the above considerations, the literature identifies a number of other related issues. The first is that only in recent years has there

been an acknowledgement of the possibility that ADD PI should be recognized as a distinct diagnostic entity. Prior to this, research categories that have been labeled ADD or ADHD have collapsed all sub-types into a single heterogeneous category. Additionally, about 25 % of children with ADD have co-occuring Learning Disability and in many investigations this has not been taken into account with regard to identifying and categorizing research subjects. In connection with this, it has been noted that great care must be taken in identifying learning disabilities since currently used criteria may confuse learning problems with specific Learning Disability. A growing consensus among researchers suggests that for Reading Disability, the underlying deficit is phonological decoding, and, that measures sensitive to this process should be used in diagnosis.

In recent literature, a concern has been raised about methodology in ADD research. With regard to investigations into similarities and differences between ADD PI and ADD H+ it is important that measures be used that do not depend on behavioral observations but instead provide insight into cognitive and neural processing of individuals with these disorders.

The Present Study

The present study is designed as a preliminary investigation into similarities and differences between ADD PI and ADD H+ in which measures of cognitive processes are employed. Recognizing that many children present with Learning Disability and comorbid ADD, such individuals are included. The study compares groups of children in the higher elementary grades (ages

9-12) who display characteristics indicative of ADD PI, ADD H+ or comorbid ADD and Reading Learning Disability. This age group is employed because, although ADD H+ is diagnosed in younger children, a secure indication of the presence of either ADD PI or Learning Disability is often difficult prior to middle childhood (Barkley, 1996). Children with Reading Learning Disability were studied primarily because research has indicated that Reading LD is more common and more readily diagnosed than other learning disabilities (Lyon, 1996). In addition measures sensitive to reading decoding, which underlies Reading LD, are readily available (Drummond, 1997).

The literature review describes the history of the development of the Das and Naglieri C.A.S. (1997) based on P.A.S.S. theory. This assessment measure is based on decades of research into cognitive assessment. Additionally the authors have made an unprecedented effort to employ an established and consistent theory of cognitive/neural processing in the development of the C.A.S. and the selection of subtests. There is considerable evidence that the subtests employed in this battery are the best known measures of the four domains of the P.A.S.S. model.

The C.A.S. measures ability in the four domains of planning, attention, successive and simultaneous processing. Although there is an apparent relationship between successive and simultaneous processing and some types of Learning Disability, a relationship between these two functional areas and ADD has not been indicated in research. Since current understanding of the foundation of ADD implicates deficits in frontal lobe function, such as planning along with selective and sustained attention then these two domains would be the most suitable focus for a preliminary investigation of

ADD sub-types using the C.A.S.

In general, the use of a validated and properly normed standardized assessment battery is superior to independent assessment measures for two reasons. The first is that although subjects should be compared only within concise age categories some variation in age is to be expected when the focus of research is on diagnostic categories. By being able to correct for the child's chronological age using normative data, analysis is simplified by not having to run separate comparisons using age as a variable. A second advantage of using a standardized battery is that it is possible to examine data, such as correlations between subtest scores in the normative sample in order to determine the suitability of various methods for data analysis in research (Tabachnick & Fidell, 1996).

Hypothesis

If the cluster of symptoms associated with ADD PI are caused by an underlying deficit in frontal lobe function, as evidence indicates is the case for ADD H+, then mean scores on the Planning domain of the C.A.S., (Das & Naglieri, 1997) will not be able to distinguish between the ADD PI and ADD H+ groups based on tests of significance.

Additional Research Questions

1) The Attention domain of the C.A.S. makes use of measures that are based on current understanding of the function of attention in humans and is

an appropriate instrument to be used to examine significant differences in mean Attention scores between ADD PI, ADD H+ and ADD with comorbid Reading Learning Disability, if such differences exist. Additionally, at the present time, research does not reveal the relative ranking of deficit in attention abilities between ADD H+, ADD PI or ADD and comorbid Reading Learning Disability . The Attention domain of the C.A.S. will be used to provide a preliminary investigation of this ranking.

2) The capability of the C.A.S. Successive or Simultaneous processing domains to distinguish between ADD PI, ADD H+ and ADD/LD (based on significant differences in mean scores) is not examined in the current study. However an examination will be made to determine if Simultaneous scores are higher than Successive scores as indicated in the results of research by Drummond (1997).

Chapter Three
Methodology

Selection of Subjects

Children, aged 9-12 years participated in this study. All were in Division II of the public school system in the City of Calgary, Alberta, a large metropolitan center with approximately 900,000 residents. In two instances children were in the process of leaving the public school system in order to be home schooled. Children were solicited through three primary institutions: 1) The Calgary Learning Centre, which specializes in diagnosis and treatment of children and adults with ADD and learning problems, 2) Dr. Oakley School, which provides educational services for children with learning disabilities and ADD, 3) Capitol Hill Elementary School. Additional solicitations were made through interested educational and health care professionals who either advertised in their respective offices or contacted the parents of individuals known to them who were potential candidates for the study.

Institutions and professionals were asked to identify individuals who had either a known prior diagnosis of Attention Deficit Disorder with or without comorbid Reading Learning Disability or those whose behavioral profile in the classroom was strongly suggestive of ADD. It was further requested that parents of all potential subjects have prior knowledge of their child's attentional or reading problems so that the primary identification of the symptom clusters did not originate with this study.

All of the children in the study who had a Reading Learning Disability

were receiving special interventions aimed at assisting them with their reading difficulties. Children with identified attentional problems had a previous diagnosis of ADD or were in the process of having potential ADD behaviors assessed by professionals. Due to limited availability of subjects with Learning Disability no particular sub-type of ADD classification was sought. However, as will be discussed, these individuals did have a uniform profile of ADD symptoms.

A total of 22 subjects were referred for the study and 18 qualified for placement in one of the three cells. Four individuals were rejected due to insufficient endorsement of ADD profile symptoms. Table 1 below provides a breakdown of subjects by classification and gender.

Table 1

Subjects by Classification

	ADD PI	ADD H+	ADD (unspecified) / LD
Male	4	4	4
Female	2	2	2
Mean Age	10.5	10.7	10.4

Screening Measures

Attention - Deficit/ Hyperactivity Disorder Test (ADHDT)

As indicated in the literature review, the DSM-IV recognizes three sub-types of Attention Deficit Hyperactivity Disorder (APA, 1994). Most of the measures used to evaluate symptoms related to ADD in children were published prior to 1994 and as such do not recognize sub-types. The ADHDT was developed by James E. Gilliam and is published by PRO-ED Inc. (1995) as a method of simplifying evaluation and diagnosis of ADD or ADHD (as it is referred to throughout the examiner's manual, based on DSM-IV classifications). This measure was normed on 1,279 subjects obtained throughout the United States and Canada and is designed for use with individuals aged 3 through 23. The ADHDT was the first measure based on DSM-IV sub type classification and additionally was the first such measure designed for use with elementary aged children and adolescents.

Validity of the ADHDT was established using recent research and by comparisons with established measures of ADD related behaviors such as the Conners' Teacher Rating Scale. Test retest reliability of the ADHDT ranges from .91 to .97 for the three subtest scales. Interrater reliability is high with average alpha levels of over .92 between teachers, parents and psychologists for the three subtest scales (Gilliam, 1995).

The ADHDT is designed in a checklist format and may be used by parents, teachers, siblings or others who are well acquainted with the individual being rated. The ADHDT is divided into three component scales: Hyperactivity, Impulsivity and Inattention. Although the criteria in the

DSM-IV (which the ADHDT is designed to supplement) includes these same three scales, the ADHDT expands the number of behavioral symptoms which must be rated. These symptoms are related to the core symptoms found in ADD or ADHD as described in diagnostic literature (Bain, 1991; Nussbaum & Bigler, 1990). In total, there are 36 behaviors that must be rated.

Examples of the 13 items from the Hyperactivity subtest include such behaviors as: being loud, constantly on the go, excessive running, jumping and climbing, excessive talking, fidgets, restless etc. The second subtest, Impulsivity, has 10 items and these include: acts before thinking, shifts from one activity to the next, impulsive, interrupts conversations and does not wait for directions. The third subtest is Inattention with 13 items and these include: poor concentration, disorganized, short attention span, difficulty staying on task and difficulty completing tasks.

On each of the three subtests, the interviewee is asked to rate the subject on all 36 behaviors on the ADHDT as either not a problem, a mild problem or a severe problem. These responses are scored as a 0, 1 or 2 respectively. Responses for each subtest are added up and entered separately. The total raw scores for each sub-type are then converted to standard scores. Each of the sub-test standard scores may then be totaled in order to determine what is called an ADHD "quotient", or, each subtest standard score may be evaluated separately using a shaded Profile of Scores chart which appears on the cover of the four page summary/response form (Gilliam, 1995). For diagnostic purposes, the subtest standard scores are added up to produce the quotient which is then used to determine the relative likelihood of ADHD using a table which provides percentile ratings.

Woodcock Reading Mastery Test-Revised (WRMT-R)

The WRMT-R (Woodcock, 1987) is a revised version of The Woodcock Reading Mastery test first published in 1973. This is a well known measure of skills essential to reading and comprehension. The WRMT-R has a long developmental history and validation trials included comparisons of scores with several well known measures of achievement and reading skills. The WRMT-R was normed on a sample of over 6,000 individuals from diverse economic and cultural groups within the United States.

WRMT-R test clusters include reading readiness, basic skills and reading comprehension. In the present study, the basic skills cluster was used for confirmation of a previous diagnosis of Learning Disability associated with reading. This cluster includes the Word Identification and Word Attack subtests. The Word Identification test requires subjects to identify 103 words. As the subject proceeds through the test they are asked to pronounce words that are found less and less frequently throughout the English language. The Word Attack test requires that the subject read either nonsense words or words with very low frequency in the English language. The 45 items on this test are selected so that the subject encounters all of the phonemes in the English language. Special attention is paid to the subjects pronunciations on all of the items as scores are based on this.

Mean split half reliability coefficients for the Word Identification and Word Attack subtests for the age group specific to this study are .95 and .92 respectively. Correlations between these two subtests are .79. The correlation between the basic skills cluster of the WRMT-R (which are made up of Word

Identification and Word Attack) and the reading full scale score is .98 (Woodcock, 1987).

Form H was used to record and score the results of these two subtests. This form conveniently allows a comparison of achievement scores to grade level.

Testing Measures

The Cognitive Assessment System (C. A. S.)

The theory and development of the Das and Naglieri Cognitive Assessment System or C.A.S. (Das & Naglieri, 1997) is discussed at length in the literature review. The eight subtests which form the basic battery of C.A.S. used in this research are described below.

Planning Tests

Matching Numbers is a four page paper and pencil subtest. Each task is composed of eight rows of numbers with six numbers per row. The length of numbers varies in each row but increases from task to task. The child is asked to find the two identical numbers in each row and the score is based on the number of correct matches along with the time on each item. Matching numbers has been used on previous P.A.S.S. factor analytic studies and has been found to be related to other planning tests (Das, Naglieri & Kirby, 1994).

Planned Codes is a paper and pencil sub test consisting of two items. A legend at the top of the page shows which two letter code (OX, XX, OO or XO) belongs with each of the letters A,B, C and D. The child employs this legend to

fill in the appropriate two letter code underneath the appropriate letters on the task. In the first task the letters are arranged in seven rows and eight columns with each column consisting of one letter only and with the A,B, C, and D in repeating order in the rows. Thus the child will complete the task most quickly if they recognize the symmetrical arrangement of letters and complete one column at a time. The second task uses a different two letter code, for each of the letters A,B, C, and D, than that used for the first task. On the second task, the arrangement of the letters is such that they are not the same in each column but are arranged in a diagonal pattern. If the child recognizes this pattern and employs it to complete one type of letter at a time (e.g A's B's etc) it will reduce his or her completion time. Scoring is based on number of letters correctly coded along with time to complete each item.

Planned codes is similar to coding tests in other cognitive batteries such as Yoakum and Yerkes (1920) however, in this instance the codes are arranged in a systematic manner. In addition, the child is not told how to complete the item but is encouraged to complete it in the manner that he or she thinks is best.

Attention Tests

Expressive Attention is designed to measure selectivity and the ability to shift attention, this sub test is modeled after the Stroop interference test (Stroop, 1935). In the first item, children are asked to read a page with the words blue, yellow, red and green printed on it in black letters. There are 40 words and they are arranged in a random fashion. The child is then administered an item in which they are required to identify the colors of a

randomly arranged selection of horizontal bars. These bars are printed in either blue, yellow, green and red and are alternated randomly. On the final item the child is presented with a page with the words blue, yellow, red and green on it, however, on this item, each word is printed in a color which is not represented by the word (e.g the word BLUE ,printed in yellow ink). The child is asked to identify the color that the word is printed in rather than read the word. Scores are based on elapsed time as well as on number of correct identifications. Only the third item is used for scoring the subtest. This sub-test has been found to load on attention in factor analytic studies (Naglieri, Braden & Gottling, 1993).

Number Detection is a paper and pencil test designed to measure. selectivity, ability to shift attention and resistance to distraction. In the first item children are asked to identify the numerals 1,2 and 3 when they are printed in an outline font from a page where there are many rows of the numerals 1, 2, 3, 4, 5, and 6 arranged randomly and printed in either bold or outlined font. The second task is more difficult because, in this instance, the child is asked to identify the numerals 1, 2 and 3 printed in bold font and the numerals 4, 5 and 6 when the latter appear in outlined font, from a page of random numbers which is similar to that presented in the first task. The child's accuracy score is based on number of correctly identified minus incorrectly identified numerals. Both accuracy and speed are used to determine a score for this subtest. This test is similar to a stimuli attention task identified by Schneider, Dumais and Shiffrin (1984).

Simultaneous Processing Tests

Nonverbal Matrices is a multiple choice test in which the child is asked to identify the missing piece of a complex colored geometric shape or to analyze the relationship in a series of colored shapes in which one part is missing and to select that part from six alternatives. The 33 items in the matrices test gradually increase in the complexity of the relationships that must be analyzed. This test is described as requiring ability in pattern completion and reasoning by analogy. Matrix type tests are one of the most widely used measures of simultaneous processing.

Verbal Spatial Relations is a test composed of 27 items in which children are presented with a page containing six drawings and a printed question at the bottom. The individual administering this test verbalizes the question which is printed at the bottom of each item and the child is asked to identify which picture represents the verbal description. Pictures include representations of people and everyday objects along with gradually more complicated relationships between simple geometric shapes such as circles triangles and squares. This test adds a verbal dimension to simultaneous tasks and is based on descriptions originally made by Luria (1966). The auditory memory component of this test is reduced by printing the question for each item at the bottom of the page.

Successive Processing Tests

Word Series is a test that requires auditory recall of lists of unrelated words that include: book, car, cow, key, dog, wall, girl man and shoe. The length of the word list gradually increases and ranges in length from two to

nine words. The appearance of each word is randomized. Repetition of words and digits was recommended by Luria (1966) and has appeared as an indicator of successive processing in many studies of P.A.S.S. theory.

Sentence Repetition is a test in which children are asked to repeat a sentence exactly as it is read to them. The sentences, such as " The yellow greened the blue." contain color words in order to reduce their meaningfulness and thus reduce the influence of simultaneous processing. There are 20 sentences in this test which range in length from three to nineteen words. Luria (1966) originally indicated that the syntactic and serial structure of speech were important in measuring successive processing.

Procedure

Initial contact was made with potential subjects by phone or in person by professionals who had agreed to assist with the project. Parents were then contacted by phone and asked to provide signed consent (see cover letter and form in Appendix A). After consent was obtained the subjects were screened for ADD and LD classification. Parents were asked to rate their child's ADD symptoms using the Attention Deficit Hyperactivity Test or ADHDT (Gilliam, 1995) in order to confirm ADD behaviors which had been identified previously by teachers, psychologists and themselves. The Woodcock Reading Mastery Test-Revised (Woodcock, 1987), Word Identification and Word Attack subtests, were then administered to the child. Children who met qualifications for the study were then tested using the Cognitive Assessment System (Das & Naglieri, 1997). This was done on a separate

occasion or following a suitable break for the child. All screening and testing was done by the author.

Testing using the C.A.S. was completed during the early morning for children who were normally regular users of stimulant medication. Parents of these children were requested that they be off of medication for 12 hours prior to testing. Testing in the early morning ensured that these children would be off of medication for the required time and at the same time not be tired from a full days activities. Estimates of required time off of stimulant medication was based on the average half life of methylphenidate, which is the most common form of drug treatment for ADD behaviors. Half-life for methylphenidate is described as being 2.4 hours and general effectiveness is lost after about 6 hours (CPA, 1998). Presence of methylphenidate in users' blood plasma is reduced to less than 5 per cent after 12 hours. To be certain that this drug would not affect testing, this time off was used as a rough guideline for parents (See consent form in Appendix A). Previous research has also used 12 hours as a guideline for time off of stimulant medications (Large, 1996). None of the children in the study were tested later than early to mid afternoon.

Use of the ADHDT in the Present Study

In the present study, the subtest scores on the ADHDT were evaluated separately. As discussed by Barkley (1996), recent research indicates that individuals with ADD PI do not endorse a large number of items from the diagnostic behaviors of Hyperactivity and Impulsivity. Thus an individual with ADD PI would only show elevated scores on the Inattention subtest of

the ADHDT. The profile chart on the cover of the ADHDT has a range of 1 to 20 . Individuals with a minimum standard score of 10 on the Inattention subtest were considered ADD PI for this study. Individuals placed in the category of Hyperactive/Impulsive type or ADD H+ had a minimum standard core of 10 on both Hyperactivity and Impulsivity subtests. These criteria require that each individual be placed in the 50th percentile or higher for each of the two sub-type categories. Note that individuals with ADD PI do not endorse enough total items on the ADHDT to produce a high overall ADD quotient because they normally demonstrate few Hyperactive/Impulsive behaviors.

An additional criteria was used to ensure proper classification of subjects. A careful note was made of ADHDT behavior items that are identical or nearly identical with DSM-IV criteria. These items were marked on the ADHDT score sheets. During ratings of subjects to confirm classification, a requirement was made that they endorse the proper number of DSM-IV diagnostic items for either the Predominantly Inattentive Type or Hyperactive /Impulsive sub types of ADD.

Use of The WRMT-R in the Present Study

The WRMT-R was used in this study to confirm previous indications or diagnosis of problems related to reading which may be classified as a Learning Disability. In each case, children so classified were required to have considerable difficulty with word recognition and pronunciation to be included in the study. As described in the literature review, current research indicates that phonetic decoding problems are directly linked to Reading LD

and thus, special attention was paid to the Word Attack test scores of the WRMT-R. In each case, the subjects were required to have a score on the Word Identification and Word Attack tests which placed them two or more years behind the reading level which was normal for their grade placement in the school system. Children who were not classified as reading LD (the ADD H+ and ADD PI groups) were required to have scores which placed them not lower than one year below normal for their grade placement. An additional requirement was that non LD subjects could not have had any previous learning difficulties that were of a nature that required special assessment or intervention.

Use of the C.A.S. in the Present Study

The required 12 hour time off from stimulant medication reduces the effect of these drugs to the point where they have no noticeable positive influence on performance. However, it increases the likelihood that the subject will have difficulties in terms of behavior and performance in extended testing. An initial trial using the C.A.S., suggested that to go beyond the eight subtests of the basic battery would create difficulties for the subject which would result in dramatic lowering of test scores. Subsequent testing demonstrated that the basic battery of the C.A.S., which took roughly 45 minute to administer, was suitable and that longer testing would have been problematic for most children. The correlations between the scores of the basic and standard battery of the C.A.S. are very high: .92 or higher in all four functional domains measured by this instrument (Das & Naglieri, 1997).

The C.A.S. provides extensive normative data and thus, standard scoring

was used for comparisons. The standards scores on the C.A.S. have a mean of 100 and a standard deviation of 15 so that direct comparisons may be made with other standardized tests. Children were tested and scored on all four of functional area of the C.A.S.: planning, attention, successive and simultaneous processing.

Analysis of Data

A factorial between subjects multivariate analysis of variance (MANOVA) was run on the results of scoring on the C.A.S. in the areas of planning and attention for the three subject groups. MANOVA is the most suitable form of analysis for variables that are moderately correlated and such is the case for test scores in the functional areas of planning and attention on the C.A.S. (Das & Naglieri, 1997: Tabachnick & Fidell, 1996). The subject groups: ADD H+, ADD PI and ADD/LD were coded 1,2 and 3 respectively and were used as independent variables. Dependent variables were normal scores on the Attention and Planning domains of the C.A.S.

In addition, comparisons were made between mean scores on the WRMT-R for the ADD H+, ADD PI and ADD/LD groups using one-way analysis of variance (ANOVA) in order to ensure that grade equivalent score/grade level differences on the Word Identification and Word Attack sub tests were significantly lower for LD subjects than for the other two groups.

Software used was SPSS version 6.1 customized for use with the Macintosh Power PC computer and licensed from the University of Calgary Computing Services Department.

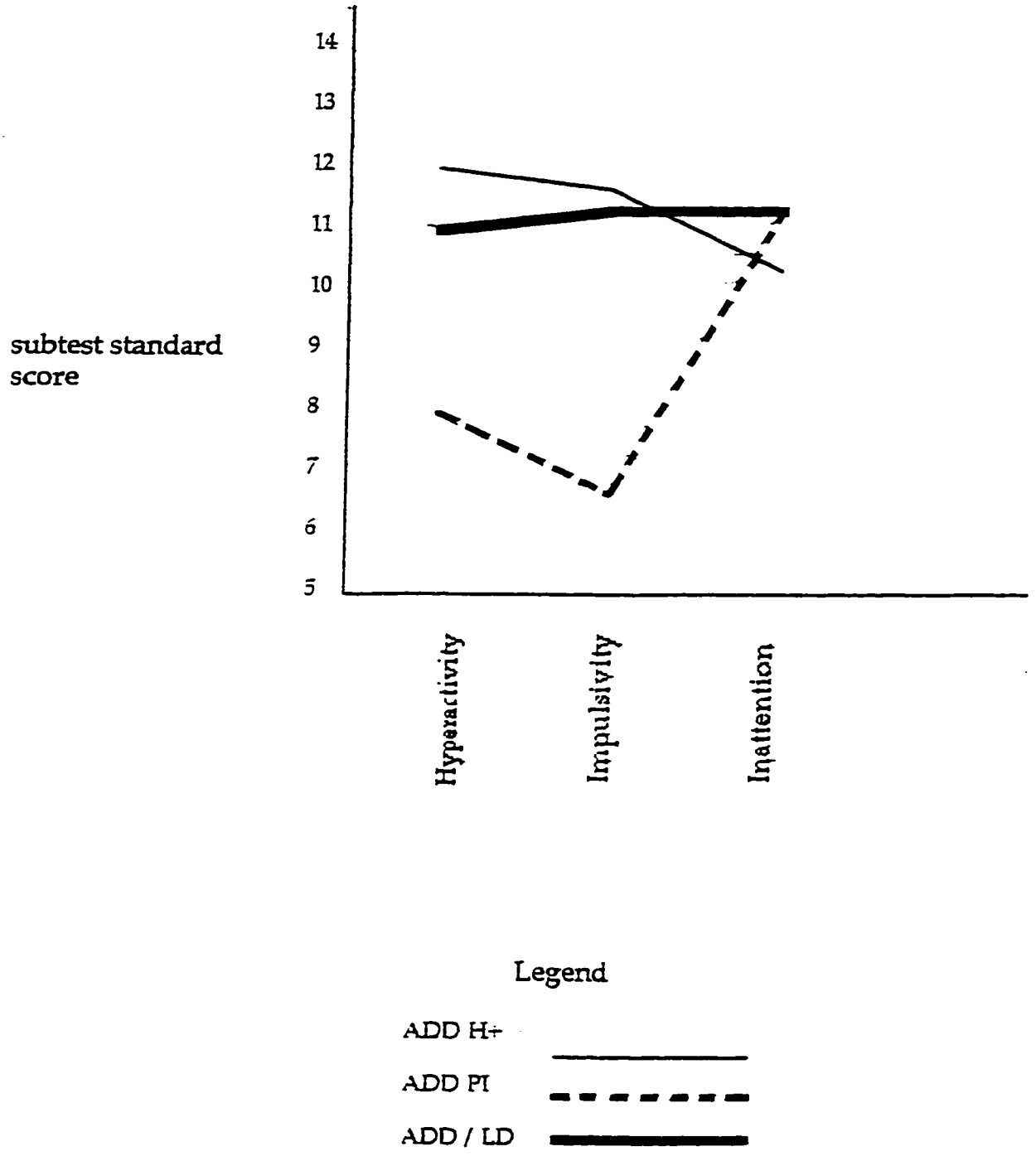
Chapter Four

Results

Screening of subjects using the Attention Deficit Hyperactivity Disorder Test (ADHDT) provided a unique profile for each of the three diagnostic categories of ADD H+, ADD PI and ADD /LD. Symptom cluster profiles are illustrated in Figure 1 and are based on the mean scores for each classification group in each of the subtest areas of the ADHDT: hyperactivity, impulsivity and inattention . Although symptom profiles for ADD H+ and ADD PI children followed expectations based on previous symptom cluster research, the profile for ADD children with comorbid Reading Learning Disability was unique and fit the criteria for ADD-Combined Type (ADD-C) as described in the DSM-IV (APA, 1994).

Figure 1

ADHDT Profiles for Classification Groups



Screening of children for Reading Learning Disability made use of grade level comparisons with grade equivalent scores on the Woodcock Reading Mastery Test, Revised (Woodcock, 1987). Table 2 below provides mean grade equivalent score/grade level-differences for each of the diagnostic categories: ADD H+, ADD PI and ADD/LD. The ADD/LD group had mean grade equivalent scores that placed them 2 or more years behind their grade placement level and analysis of variance (ANOVA) showed the difference scores for this group to be significantly below those of the ADD H+ and ADD PI groups .

Table 2

Mean WRMT-R Grade Equivalent Score/Grade Level Differences by Classification

	ADD H+	ADD PI	ADD /LD
Word Identification	.40 above grade placement	2.9 above grade placement	2.0 below * grade placement
Word Attack	2.0 above grade placement	2.4 above grade placement	2.3 below ** grade placement

** denotes $p < .01$

* denotes $p < .05$

Testing with the basic battery of the Cognitive Assessment System or C.A.S. (Das & Naglieri, 1997) yielded scores on the four domains of planning attention, successive and simultaneous processing along with full scale scores. Means and standard deviations for these scores are provided in Table 3.

Table 3

Summary of Scores from C. A. S. Basic Battery

	ADD H+		ADD PI		ADD / LD	
	mean	st. dev.	mean	st. dev.	mean	st. dev.
Planning	89.5	7.3	87.0	8.6	90.2	15.2
Attention	92.5	7.3	102.0	12.2	87.2	8.5
Simultaneous	105.0	4.4	112.3	9.9	102.5	10.3
Successive	107.7	11.9	106.0	9.6	105.0	16.3
Full Scale	98.6	7.3	102.7	4.5	94.16	13.7

A factorial, between subjects, multivariate analysis of variance was conducted on two dependent variables: planning and attention. Independent variables were the diagnostic categories of ADD H+, ADD PI and ADD/LD. Tests of linearity and homogeneity indicated the suitability of the data for use in this type of analysis. In particular, because even cell sizes were employed robustness of tests of significance were expected. Generally in multivariate analysis in which more than one diagnostic group are being employed as independent variables Wilks Lambda criterion is used as the multivariate test of significance. Wilk's Lambda is the pooled ratio of error variance to effect variance plus error variance. However, due to the relatively small sample size, Pillais criterion which is simply the pooled effect variances, was considered the most robust test of significance in this analysis (Tabachnick & Fidell, 1996).

For Pillais criterion, significance was $F(4,30)= 2.40$, $p > .05$ ($p=.074$) and thus the combined dependent variables of Attention and Planning were not significantly affected by membership in any of the three diagnostic categories. However, with SPSS MANOVA, Wilk's Lambda, which was not considered as the primary test criterion in the current study, is provided as an additional test. Significance for Wilk's was: $F (4, 28)= 2.73$, $p <.050$ ($p=.049$). Due to this result, univariate analysis was examined to see if either Planning or Attention domains contributed significantly to the analysis. Planning did not contribute to the analysis- $F (2,15)= .14$, $p >.05$. Attention showed a modest contribution: $F (2,15$ d.f.$)=3.69$, $p = .050$.

Based on the above results, the hypothesis that the ADD PI and ADD H+ groups are different based on scores of the 'Planning' domain, as tested by the

C.A.S., is rejected. However, subsequent exploration was undertaken by using one way analysis of variance (ANOVA) on each of the three possible combinations (pairings) of the three diagnostic categories. This was conducted in order to determine if the Attention domain was able to distinguish between any of these pairings (e.g. ADD PI-ADD H+, ADD PI-ADD/LD or ADD H+- ADD/LD). This analysis revealed that the mean scores on the Attention domain of the C.A.S. were able to distinguish ADD PI from ADD /LD at univariate F (1,10)=5.93, p <.05 (p=.035).

Ranking of the diagnostic groups based on mean scores of the Attention domain of the C.A.S. are, from highest to lowest: ADD PI, ADD H+ and ADD/LD. For the diagnostic category of ADD/LD the mean scores for Successive processing are higher than for Simultaneous processing. As stated in the section labeled "Other Research Questions", no test of significance was applied to this data.

Chapter Five
Discussion

Planning

This study was designed as an initial exploration into the relationship between the two most widely recognized sub-types of Attention Deficit Disorder: the Predominantly Inattentive Type and the Hyperactive/Impulsive sub-type. Further, it is the first investigation of its type that makes use of a validated and normed measure of cognitive processing that was based, from its inception, on a well established model of human neural processing. As described previously, the most widely agreed upon model of dysfunction in children with ADD H+ involves deficits in functioning in the frontal lobes of the brain (Barkley, Grodzinsky & DuPaul, 1992; Chelune, Ferguson, Koon & Dickey, 1986). What is not known is whether a similar deficit is responsible for the symptoms seen in ADD PI (Barkley, 1996; Stewart, 1994). It was hypothesized that if such a deficit did exist in children with ADD PI, that mean scores in the area of Planning (a domain that is primarily associated with frontal lobe functioning) would not be able to distinguish between ADD PI and ADD H+.

Results of the analysis indicate that the scores in the Planning domain of the Cognitive Assessment System could not differentiate between ADD PI, ADD H+ or the ADD/LD groups of children. In fact, the similarities between the mean planning scores as illustrated in Table 3 on page 50 are quite striking and the non-significance found in the analysis is therefore not surprising.

Comparing the scores in Table 3 to those obtained by Das and Naglieri in the preparation of the C.A.S. it was noted that mean scores for the Planning domain are 88.4 for an undifferentiated ADD sample in their study as compared to 89.5, 87.0 and 90.2 for the ADD H+, ADD PI and ADD/LD groups respectively in the present study (Das & Naglieri, 1997). The similarity in mean Planning scores between the two studies is more striking when one considers that the Das and Naglieri research included roughly three times as many subjects (n=66) as the current research.

The subtests included in the Planning domain in the basic battery of the C.A.S. are Matching Numbers and Planned Codes. Interestingly these two tests are designed so that they require both speed (as they are timed tests) and accuracy. Children with ADD H+ completed the two subtests very rapidly but often made a number of misidentifications of numbers in the Matching Numbers subtest or else used the wrong two letter codes in the Planned Codes subtest. Conversely, children with ADD PI appeared to complete the test more slowly but made less of the types of errors just described. Children with ADD/LD did not appear to rush through these subtests in a manner similar to children with ADD H+. In spite of these general observations there were exceptions, and particularly in the ADD H+ group there were children who, although appearing to rush through the test, had considerable accuracy. These ADD H+ children have apparently learned some strategies that allow them to balance their apparent impulsivity with accuracy.

The second task of the Planned Codes subtest has letters A,B, C, and D repeating in each row, however, identical letters form a diagonal pattern on the page. This contrasts with these same letters appearing in a more easily

recognized vertical pattern on the first task (A,B,C and D appear directly on top of the identical letter as you go from row to row). Children are asked to observe the pages before starting, and in the case of the second item, in the hope that they will notice the diagonal pattern and thus speed up their completion rate. Two of the ADD PI children noticed this pattern before beginning this item. Only one ADD H+ individual noted the pattern prior to starting the second item. One child in the ADD/LD group noticed the pattern only after they were close to completing the item.

When considering the foregoing observations of the types of errors that are being made by different classifications of children it is tempting to think that the differing types of errors that each group makes may pertain to real processing differences. However, during preliminary design of the subtests for the planning domain, Das , Naglieri and Kirby (1994) recognized that organizing a given task is just as critical as resisting the impulse to undertake a task in a haphazard fashion. An examination of the literature which describes neural correlates of cognitive function indicates that both of these skills are mediated by frontal lobes of the brain (Kalat, 1995). To restate this, although impulsivity is evidently a dysfunction endemic to ADD H+ and lack of organization is apparently a deficit in children with ADD PI, both of these abilities are mediated by frontal lobe function. The observable dysfunction in children with ADD PI is not surprising when one considers that all of their parents endorsed items pertaining to forgetfulness, disorganization and poor planning ability on the Inattentive scale of the ADHDT (Pro-ED, 1995). Parents of the ADD H+ and ADD /LD groups of children in the study also frequently endorsed items pertaining to

forgetfulness and poor planning ability. However, when asked for clarification it seemed that impulsivity and haste in everyday activities were the underlying cause of problems in these children in contrast to general slowness and absentmindedness in ADD PI children. This is consistent with the observations of general behaviors in these sub-types of ADD (Lahey & Carlson, 1991).

When one considers the types of cognitive skills that are involved in what is termed "planning" the question arises as to whether or not the Planning subtests of the C.A.S. actually encompass all of these. In general terms many human activities are included in the rubric of planning ability. From experience we know that planning includes many complex activities that range from finding our way to a specific address in a strange city to deciding the appropriate steps in the construction of a new housing development. In each case there is considerable freedom (such as different routes to the same address), however, there are also constraints and limitations to consider with each option. Additionally, there are some options that are more expedient than others. When we examine the Planning tasks on the C.A.S. we note that there are limitations on the number of choices that a child has to complete a task. However, when these tasks are compared to the others on the C.A.S. it is noted that there is more flexibility in the ways that the Planning tasks may be completed than on the subtests of any of the other domains.

To summarize, the C.A.S. Planning subtests allow a choice among limited options in completing a task. As with more complex tasks involving planning there is a most efficient way to complete each task along with less

efficient ways. Within the constraints of a paper and pencil test, these tasks encompass most of what we might include in the domain of planning. The only exception to this may be the lack of a strong temporal component which exists when we try to envisage the timing of various components of a long range plan.

As regards the theory of ADD H+ as put forward by Barkley (1996) which implicates deficits in what is termed "executive function" we might also ask if the present findings suggest that ADD PI shares this deficit. Barkley's theory appears to encompass practically all of the functions which are mediated by the frontal cortex of the brain. Although Barkley does not use the specific term "planning" in his schematic description of his theory, terms such as analysis and synthesis", "inhibiting task irrelevant responses" and "executing goal directed motor responses"(p.70) may be included under this rubric. It should be noted that Barkley's theory does include a strong temporal component which would be difficult to operationalize and which, for practical purposes, the C.A.S. does not include. Thus the C.A.S. Planning tasks do encompass a number of the tasks involved in executive function: at least those that are measurable in any practical sense using cognitive assessment. Other components of Barkley's model encompass long term goals, internal language and moral reasoning, abilities that are difficult to quantify much less measure. Interestingly, these abilities are deemed by many researchers to be specifically human and evidence suggests that these are mediated by the frontal cortex which is much more extensive (and larger in relation to overall body size) in humans than in any animal group (Eccles, 1993).

Mean scores on the C.A.S. Planning domain (Das & Naglieri, 1997) were

unable to distinguish between the three diagnostic categories. The similar diagnostic profile of ADD H+ and ADD /LD on the ADHDT (e.g. high hyperactivity and impulsivity scores) would not make this a surprising result if these were the only two groups being compared. However, in the analysis the Planning domain could not distinguish ADD PI from ADD H+ either. Based on the conclusion from the literature that a frontal lobe deficit underlies ADD H+, and since planning is a measure of frontal lobe functioning, it would appear that some ability which is controlled or mediated by the frontal lobes of the brain underlies ADD PI as well. This conclusion would, of course, be strengthened if the results of the current study were to be replicated.

Attention

As indicated in the results section, scores on the Attention domain were unable to distinguish between the three diagnostic categories using the Pillais criteria. An examination of the analysis showed that for Wilks test, a significance of .049 was achieved. Examination of univariate statistics indicated that groups may be separated by scores of the Attention domain of the C.A.S although significance was exactly .050. Due to the ambiguity of this result an analysis of variance was conducted on each of the three possible combinations of the groups in order to determine which, if any, were distinguishable by the Attention scores. As anticipated from an observation of the groups means shown in Table 3, the ADD PI group and the ADD /LD were distinguishable based on mean scores on the Attention domain of the C.A.S.

The conclusion that can be drawn from this analysis and observation of the Attention domain are necessarily tentative. This is partly because separation of the groups was not significant at very low levels of probability (multivariate for Attention was p=.049, univariate between ADD PI and ADD/LD for Attention was p=.035). More importantly however, the profile of symptoms (as indicated using the ADHDT and as shown in Figure 1) for ADD H+ and ADD/LD are similar to each other and also quite distinct from that of ADD PI. This begs the question of why significant separation was not achieved between the ADD PI and ADD H+ groups as well. In fact, an observation of the Attention scores does indicate that there is a considerable spread between those of the ADD PI and ADD H+ groups. A replication of the same study using more subjects would provide evidence that might resolve this question.

What is of most interest with regards to the results of the current study is that the ADD/LD children had the lowest scores in the domain of Attention but not significantly lower than those of children with ADD H+ group. Scores in the Attention domain are provided in the C.A.S. manual for a group of children with reading disability and for a group with heterogeneous ADD, mentioned previously. Attention scores for the ADD children described in the C.A.S. manual have a mean value of 92.1 compared to 92.5 for the ADD H+ group in the current study. Attention scores for a sample of 24 children children with reading Learning Disability described in the C.A.S. manual are 91.1 compared to 87.2 for the combined ADD/LD group in the present study. One possible conclusion from this is that specific Learning Disability interacts with Attention Deficit Disorder to produce a more severe deficit in the domain of attention.

Another possible way of addressing the issue of attention is to examine the content of the subtests which make up the Attention domain of the C.A.S. The first subtest, called "Expressive Attention" (Das & Naglieri,1997), is actually a version of the Stroop interference test and is described in the chapter on methodology in this study. In this test the child must disregard the word that is presented and instead concentrate on identifying the color that it is printed in. According to Rothbart, Posner and Hershey (1995) this test makes use of the Anterior Attention Network. The second attention subtest is called Number Detection and involves detecting, from an array of numbers, those that are printed in a specific font. Although this test may involve selective attention and thus the posterior attention network it also requires resistance to interference from irrelevant input which requires skills similar to the Stroop test. Both the Expressive Attention and Number Detection subtests make use of elapsed time and accuracy for scoring.

Although there does not appear to be anything contained in the elements of these two Attention subtests that might be a particular problem for children with reading LD, observations of testing behaviors may be relevant. In the case of the Stroop type test contained in the Expressive Attention it was noted that children with ADD H+ were able to proceed through the test with considerable speed and accuracy. Children with either ADD PI or ADD/LD were generally slower at this task but accuracy was similar across all three groups. Also, all three groups displayed similar ability on the first item of the Number Detection subtest in which they merely had to find the numbers 1, 2 and 3 printed in an outline font from an array of the numbers 1, 2, 3, 4, 5 and 6 printed in either outline or solid font. On the

second item however, they were asked to find the numbers 1, 2 and 3 printed in solid font as well as the numbers 4, 5 and 6 printed in outline font. In this case the ADD PI group demonstrated superior accuracy and speed than either the ADD H+ or ADD /LD groups. The children with ADD H+ attempted to move through this test rapidly and often misidentified numbers whereas the ADD/LD children had difficulty with speed and accuracy. Since the presentation in this test involved numbers only, it is difficult to conceive of how having Reading Disability might create problems for these children.

In light of the fact that children with pure Reading Learning Disability described in the C.A.S. manual had higher attention scores than the ADD/LD group in this study it seems more reasonable to conclude that there is an interaction taking place that is producing even greater deficits related to attention. One caution in comparing the reading LD group in the C.A.S. with the ADD/LD group in this study is that criteria for reading LD for the latter group of children appears to be more specific. In the C.A.S. manual, for the test population of Reading LD children, there does not appear to be a requirement for prior identification of Reading Disability related to phonetic decoding.

With regard to the Attention domain, the goal of this study was an exploration based on comparisons of the mean scores for each group. In general the mean scores for this domain are not surprising when one considers attention deficits in isolation. As described above, the Attention subtests of the C.A.S. are designed to tap into specific neural processing as outlined in modern attentional theory (Rothbart, Posner & Hershey, 1995). One apparent contradiction in the results of this study is that individuals with

ADD PI endorse a high number of items on the Inattention scale of the ADHDT but have the highest mean ability scores in the domain of Attention on the C.A.S. However, the Inattention scale on the ADHDT contains elements related to frontal lobe function such as disorganization, forgetfulness and poor planning ability as described above, along with items related specifically to attention. Thus we would not expect to find complete agreement between the ADHDT and the C.A.S. Attention domain.

The ranking of the Attention domain scores of the C.A.S. places the ADD PI group highest in ability followed successively by the ADD H+ and ADD/LD groups. Although the literature is relatively silent about the interaction of ADD and LD relative to quantifiable attention abilities, ADD PI is considered to be a less severe form of attention deficit and this is reflected in the current findings. As stated in the literature review, there is some conjecture as to specificity of ADD sub-type being related to dysfunction in one or the other attention network. However, as also noted, the interrelationship of the function the Anterior and Posterior Attention Networks makes it unlikely that an etiological distinction can be made strictly on this basis. Nevertheless since the tasks in the C.A.S. Attention subtests appear to depend more on the Anterior Attention Network which is implicated more in ADD H+ (Barkley, Grodzinsky &DuPaul, 1992) and since the children with ADD H+ had lower scores compared to the ADD PI group this line of reasoning may warrant further investigation.

With regard to the Attention domain, the results of the current study offer some reason for conjecture. However, before any firm conclusions may be made it is important that a study similar to the current one be undertaken

with a larger sample.

Relationship of Learning Disability to ADD

During the planning of the current study, a decision was made from the very beginning to include children with comorbid Attention Deficit Disorder and Reading Learning Disability. Due to the relative difficulty in finding subjects who had been diagnosed with both disorders, it was decided to not place any particular restriction on the sub-type of ADD that these subjects had. Parents of the majority of ADD/LD subjects described their children as merely having Attention Deficit Disorder. Although most parents were not aware of a particular sub-type diagnosis for their children with Reading LD, most did endorse symptoms of hyperactivity and inability to concentrate for their children.

The purpose of using the ADHDT in the current study was to confirm a symptom cluster that had been identified previously rather than to provide an independent diagnosis. In spite of this, ratings by parents of children with comorbid ADD/LD on the ADHDT did reveal a surprisingly consistent profile of symptoms which is indicated in Figure 1 in chapter 3. What was most surprising, aside from the consistency of the ratings between ADD/LD subjects, is that the symptom profile is indicative of the DSM-IV diagnostic category of ADHD Combined Type (APA, 1994). As described in recent research literature this diagnostic sub-type is not reflected in factor analytic studies aimed at separating ADD symptom profiles (Barkley, 1996) and was not intended to be included in the current study. Original consideration of the

Combined sub-type as a diagnostic entity was provided in the field trials for the DSM-IV(Lahey, Applegate, Mc Burnett & Biederman, 1994) and in subsequent research in which DSM-III and DSM-IV classifications have been compared (Morgan, Hynd, Riccio & Hall, 1996).

A study by Gaub and Carlson (1997) compared the behavioral characteristics of a population of 221 school aged children with an equal number of controls. Diagnostic clusters in the subject groups included children with identifiable ADD H+, ADD PI and ADD combined type based on DSM-IV criteria. Comparisons were made to teacher ratings of behavior, academic and social functioning. The ADD PI group showed impairment in all areas but with appropriate social behavior. The ADD H+ group had more externalizing and social problems but had academic functioning that was on par with the children in the control group. The children described as having ADD-Combined Type showed severe and pervasive difficulties across domains including academic achievement.

The parallels between the Gaub and Carlson (1997) study described above and the results of the present study are striking in the light of the consistent endorsement by the parents of children with Reading Learning Disability, of the DSM-IV symptom profile of ADD-Combined Type. Presumably, although not stated specifically by Gaub and Carlson, the children with ADD-Combined Type who had severe academic problems would include specific learning disabilities. In addition, although the behavioral presentation of subjects was not an area of intended investigation in the current study, the evidence given by Gaub and Carlson of social and academic problems in ADD-Combined children provided a means of comparison.

During testing in the present study the ADD/LD children were often withdrawn and shy and most were initially resistant to testing in spite of encouragement from parents. By comparison the children with ADD H+ were outgoing and appeared comfortable with adults and were highly cooperative in testing. The children with ADD PI were not as forward or outgoing as the ADD H+ group and although somewhat shy, they tended to have a presentation which appeared appropriate for a child asked to work with an adult who was unfamiliar to them.

In the research literature, children with ADD PI are reported to have an apparent slowness of processing which is somehow reflected in their behavioral presentation (Barkley, 1996). In addition this presentation is said to be comparable to children with specific Learning Disability, at least in terms of behavioral profile (Lahey & Carlson, 1991). The results of the current study tend to reinforce these observations of behavioral presentation. However the source of these parallels is somewhat puzzling in light of the fact that, in the present study, children with ADD/LD have an ADD symptom profile that is much closer to children with ADD H+ and the fact that children with ADD PI are the best readers.

It may be possible that children with ADD-Combined Type have a specific and relatively severe form of attentional problem that generates problems with learning and processing of information. A possible mechanism for this is suggested by Swanson (1991) in which children with LD require a tremendous amount of effort in order to allocate the required level of attention necessary to encode information. This involves sustained attention and it is this type of attention that is described as being the most

difficult for children with ADD H+ and presumably for children with the Combined Type of ADD (Barkley, 1996; Lahey & Carlson, 1991). The mechanism described by Swanson also includes deficits in memory and allocation of resources across brain hemispheres. Although discussion of such complex mechanisms is beyond the scope of the present study, evidence does exist of a close connection between Attention Deficit Disorder and learning disabilities. Future studies should, among other priorities, further examine the consistency of the association between ADD-Combined Type and Reading Learning Disability which was observed in this study.

Successive and Simultaneous Processing

Although the domains of successive and simultaneous processing were tested in the current study there was no specific analysis of this data. While testing of these domains could have been left out of the study altogether it was felt that all children in the project should be tested using a complete form of the C.A.S., in this case the basic battery. The specific order of testing domains of the C.A.S. follows the pattern of Planning, Simultaneous Processing, Attention and finally Successive Processing. It seemed that if this order was changed it might produce a confound which may limit the possibility of the current data being compared to that of future research in which all four domains are used for the analysis. In addition, if the possibility arose of combining the current data with future test data, sufficient numbers of subjects may be acquired to allow multivariate analysis using all four domains as dependent variables. In the current study the number of subjects

involved allowed reasonable statistical power with two dependent variables in the analysis.

In addition to the above, at the present time there is no specific theory regarding any relationship between Attention Deficit Disorder and simultaneous or successive processing of information that might warrant testing. The only finding from previous research that is relevant to the current study is that children with reading disability tend to have better successive processing ability as compared to simultaneous processing (Drummond, 1997; Kirby & Robinson, 1987). Studies with heterogeneous male ADD populations indicate low successive scores as compared to controls without ADD (Reardon and Naglieri, 1992). In the current study scores on both Simultaneous and Successive domains of the C.A.S. were lowest for the ADD/LD group and somewhat higher for the ADD H+ group. The children with ADD PI had the highest scores in both of these domains. Additionally, the children with reading learning disability had higher Successive than Simultaneous scores which is opposite of the findings of studies by Drummond or Kirby and Robinson.

Diagnostic Changes Over Time

As indicated in the chapter on methodology, four subjects were excluded from the study because of failure to meet diagnostic criteria. In one instance a child with Reading Learning Disability had a diagnosis of ADD H+ made while in the first grade. During screening it was noted that the child no longer met criteria for ADD of any sub type. The child's mother stated that she

had suspected this since her child had demonstrated fewer problematic behaviors related to hyperactivity and impulsivity over time, while continuing to exhibit problems with reading. In another instance a mother indicated that her child, currently in the fifth grade, displayed behaviors prior to age nine that were indicative of ADD H+ even though the current diagnosis was of ADD PI. No formal diagnosis had been made prior to age nine however the mother was insistent that the child would have easily met diagnostic criteria for ADD H+ at that time.

Both of these revelations were somewhat surprising. However Barkley (1996) has hinted that ADD H+ and ADD PI symptomology may be linked to childhood developmental changes. Consistent with the example given above, Barkley indicates that symptoms of ADD PI often develop in later elementary years. Stewart (1994) has also indicated that there is evidence of diagnostic changes over time in children and adolescents with ADD. As stated in the literature review, ADD PI is rarely diagnosed in early elementary years and thus the current study involved children who were enrolled in later elementary grades. This information serves to remind us that any conclusions regarding childhood psychological disorders including ADD and LD must be tempered by an understanding of their developmental context. This indicates that findings in future studies that make use of C.A.S. scores, may have to be compared using a longitudinal design in which children in upper elementary grades are retested in their early teens.

Familial and Genetic Association of ADD Sub Types

As noted previously, one of the major goals of the current study was to examine the relationship of ADD PI to ADD H+. Although the intent was to examine this relationship through performance on Attention and Planning Domains of the C.A.S. another avenue of possible future research was revealed during testing. In discussing the history of their child's ADD symptoms many parents revealed that they were aware of first generation relatives with ADD. Often these parents revealed that they themselves either had been diagnosed with the disorder or suspected that they had ADD. Most notably, some parents indicated that there were individuals with both ADD H+ and ADD PI in the same family. These families indicated a knowledge of the differences in diagnostic criteria for both sub-types of ADD. When such criteria were reviewed in detail with them, they confirmed the existence of both sub-types within their families. Almost all of the well known publications on ADD describe the familial and genetic associations of ADD, and parents of ADD children often are aware that it "runs" in families. What is under reported in the literature is the possible genetic association between ADD PI and ADD H+ that was evidenced in discussion with parents. Such an association, if confirmed by a thorough investigation of genetic relationships, would strengthen the argument that ADD PI and ADD H+ have a common underlying etiology.

Limitations of the Current Study and Future Directions

The current study involved a relatively small number of subjects to investigate the relationship between ADD PI, ADD H+ and comorbid ADD and Reading Learning Disability. Part of the strength of the current study was making use of fairly strict criteria for confirmation of diagnosis of subjects. In future research it would be helpful to include larger numbers of children with ADD or learning disabilities. Using larger numbers of children may also allow an examination of the connection between ADD and learning disabilities other than Reading Disability. Obtaining these subjects may require the involvement of a number of schools and other institutions. However, such research would be useful in confirming the findings from the present study and resolving such issues as the relationship of relative attention ability to sub-type of ADD or comorbid ADD and LD.

In addition to the above, future research should examine the symptom cluster associated with ADD combined type and its relationship to learning disability. Other research aimed at resolving the issue of a possible genetic relationship between ADD PI, ADD H+ and learning disabilities would be of interest. The conclusion from the current study is that the Das and Naglieri C.A.S. (1997) is a suitable measure for comparisons of ability between diagnostic groups in future research.

Chapter Six

Summary and Conclusion

Although Attention Deficit Disorder, Predominantly Inattentive Type (ADD PI) is now recognized as a diagnostic category that is distinct from Attention Deficit Disorder, Hyperactive/ Impulsive Type (ADD H+), historically, in research and clinical practice this has not always been the case. In addition there is a lack of research data which allows a clear understanding of differences and similarities between these two sub-types of ADD based on our current level of understanding of neurological processing in the human brain. Research indicates that the neural substrates that are related to ADD are the frontal lobes along with the two most well established attention systems known as the Posterior and Anterior attention networks (PAN and AAN). Cognitive assessment tools that might be useful in distinguishing valid similarities and differences between ADD PI and ADD H+ must be those that operationalize the cognitive correlates of these systems and must not rely on behavioral observations. The Cognitive Assessment System (Das & Naglieri, 1997) is an instrument which qualifies for an investigation of similarities and differences in ADD sub-types based on the above criteria.

Years of clinical practice and research have also indicated that about 25% of children with ADD have co-occuring learning disabilities, most often related to reading difficulties. Research into the characteristics of ADD children have often used heterogeneous populations and have not made a clear distinction between subjects with ADD only and those with comorbid ADD and a specific Learning Disability. Few of these studies have targeted the

specific interactions of attentional problems with Learning Disability.

The current study is an investigation of similarities and differences in children with ADD PI, ADD H+ and comorbid ADD and LD using the Attention and Planning domains of the Das and Naglieri C.A.S (1997). The Planning domain of this instrument has been shown to be a valid measure of cognitive functioning of the frontal lobes of the human brain. The Attention Domain of the C.A.S. was designed to measure functions which are controlled by the PAN and AAN.

Results of the study indicate that, based on mean C.A.S. (Das & Naglieri, 1997) Planning domain scores, the three diagnostic categories described above cannot be distinguished using tests of statistical significance. This suggests that a common frontal lobe deficit underlies ADD H+ and ADD PI. Attention problems for the group of children with comorbid ADD and LD, as measured on the Attention domain of the C.A.S., are greater than for the other two diagnostic groups. Differences in the Attention domain between the ADD/LD group and the ADD PI group may be statistically significant however results are somewhat ambiguous. Finally, the ADD/LD group meets the DSM-IV diagnostic criteria for what is called ADD-Combined Type (APA, 1994).

The most secure conclusion based on the present study is that a frontal lobe deficit underlies the etiology of both ADD PI and ADD H+. This, along with indications from subjects families that ADD PI and ADD H+ are found in the same biologically related families, suggests a strong relationship between these two sub-types of ADD.

At the present time there is still a considerable amount of controversy over the underlying neural deficits of ADD and Learning Disability. Uncovering the neural correlates of LD and ADD is of scientific interest and, for the future, this effort may provide an essential first step in finding new treatments for these disorders. In order to begin such a course of discovery it is essential that the relationship of the sub-types of ADD with each other and with specified learning disabilities be examined. Presently, there is a secure body of research that has uncovered the essential neural correlates of ADD H+ along with the human cognitive function that we call "attention". By using these as a starting point and comparing research data, the relationship of current theory to unsolved puzzles such as the etiology of ADD PI may be uncovered.

In order to conduct the research that is necessary, new measures are required that have been designed based on a solid theoretical foundation. In the case of the C.A.S. (Das & Naglieri, 1997) used in the current study, the researchers involved have rightly concluded that cognitive measures must be correlated with the results of research into the function of the human brain. A large body of knowledge with regard to human cerebral processing has existed for some time now however the C.A.S. is the first paper and pencil test of human cognitive function to be based on this knowledge from its inception. As such it is ideal for an investigation of the type which has been undertaken in the current study.

Although the current study is a necessarily small one, a number of issues with regard to comparisons, inclusions and research measures have

been addressed in a way that has not been done in prior research. It is hoped that this will be the first of many studies that will attempt to address legitimate criticisms that have been leveled at past ADD-LD studies.

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Appendix A

Cover Letter

Dear Parent / Guardian:

My name is Brad Dye. I am a graduate student in the Program in Clinical Psychology at the University of Calgary, conducting a research project under the supervision of Marilyn Samuels Ph. D as part of the requirements for a M.Sc degree. I am writing to provide information regarding my research project which examines cognitive processing differences among children with Learning Disabilities and Attention Deficit Disorders so that you can make an informed decision regarding your child's participation.

The purpose of the study is to examine the different ways in which children with attentional problems, with or without a specific learning disability, process and attend to various types of information. As part of the study your child's attention behaviors will be rated by myself and either yourself or your child's teachers. In addition your child will be given a short (roughly 15-20 minute) written test designed to assess his or her reading level. Although your child has been identified as potentially meeting the requirements for this study it does not mean that he or she has Attention Deficit Disorder or a Learning Disability. If your child has not had a previous diagnosis of Attention Deficit Disorder or Learning Disability and you are concerned about the possibility of having this diagnosis made please feel free to contact myself or my supervisor at the numbers provided on the next page. If you give consent to have your child's attention behaviors and reading

ability rated and following this, if your child meets the qualifications for the study, you will be contacted and asked if you would allow him or her to take a paper and pencil test called the Cognitive Assessment System published by Riverside Publishing Company in 1997. The test requires your child to compare letters and numbers or shapes, recite word or sentences from memory, match words and pictures or letters and numbers and to look for distinct letters and numbers.The test will take approximately 60 minutes and your child will be allowed a short break during testing if he/she so requests. Your child will have the purpose of the test described to him or her before hand and will be debriefed afterwards.

If your child is currently taking medication for the symptoms of Attention Deficit Disorder it is required that he/ she be off of medication for no less than 12 hours prior to testing. In such a case, the assessment will be scheduled for the morning and your child will receive medication, provided by yourself or your child's school, immediately following testing. This will not incur any additional risk to your child.

You should be aware that even if you give your permission in this study, you and your child are free to withdraw at any time for any reason without penalty. Similarly, I can terminate your child's participation at any time for any reason. In such a case, I will inform you of those reasons.

Participation in this study will involve no greater risk than is experienced in daily life. Results of the testing may provide a more precise idea of how your child processes information. The general report of the testing results will be provided to you by phone, if you so desire. Note that such general results do not include scores or percentile rankings but only

general information about your child's ability in the areas being tested. Additionally, if you feel that the general results may be of benefit to your child's teachers or other school staff in order to assist in facilitating your child's education, you may request that they be provided to the school. No individual results will be given to your child's school without your written permission.

Data will be gathered in such a way as to ensure anonymity. Your child's name will not appear anywhere on the answer or scoring sheet for any of the tests and results will not appear in any written or electronic form in combination with your child's name, address or other information which would allow personal identification. During the collection and analysis of data, a coding system will be used to protect your child's identity. Once collected, responses will be kept in the strictest confidence and only group results will be reported in any published studies. The raw data will be kept in a locked filing cabinet at the University of Calgary, only accessible to me and my supervisor. All files will be destroyed three years after completion of the study.

If you have any questions, please feel free to contact me at 289-7946, or my supervisor, Marilyn Samuels, at 220-8566. A copy of the consent form is provided. Please sign and return this to myself, using the enclosed envelope, as soon as possible. A copy will be provided to you for your records.Thank you for your cooperation. Sincerely,

Bradley G. Dye

Consent Form

Consent for Research Participation

Cognitive Processing Differences in Children with Attention Deficit Disorder, Predominantly Inattentive Type

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what research is about and what your participation will involve. If you would like more detail about something mentioned here, please ask. Please take the time to read the form carefully and to understand any accompanying information.

I/ We, the undersigned, hereby give my / our consent for

_____

to participate in a research project which examines cognitive processing differences among children with Learning Disability and Attention Deficit Disorder.

I / We understand that such consent means that

_____ will have his / her attentional behaviors and reading ability rated which may involve working through a written test (roughly 20 minutes) as well as short interview with myself / ourselves with regard to my / our child's behaviors. I understand that consent also means that my / our child may be administered a short (approx. 60 min.) test that requires him / her to engage in a variety of tasks designed to

examine the different ways in which children process information. These tasks include comparisons of letters and numbers or shapes, reciting word or sentences from memory, matching words and pictures or letters and numbers and looking for distinct letters and numbers. I understand that I will be contacted by phone prior to the administration of this test. This testing will be done at the student's school or home, The University of Calgary clinic, or at The Calgary Learning Centre during the day at a mutually agreeable time.

I /We understand that it is required that if _____ is currently taking medication for the treatment of Attention Deficit Disorder that he/ she be off of medication for twelve hours prior to testing. In such case all efforts will be made to schedule testing in the morning so that the child may receive medication prior to engaging in the rest of the days activities. We also understand that that this will not pose any additional risk to my /our child.

I / We understand that participation in this study may be terminated at any time by the request of myself/ ourselves, my child, or that of the researcher. Participation in this project and / or withdrawal from this project will not affect my / our request or receipt of other services from the Calgary Board of Education, The Calgary Learning Center or the University of Calgary.

I/ We understand that this study will not involve any greater risks than those ordinarily occurring in daily life.

I/ We understand that the responses will be obtained anonymously and kept in the strictest confidence.I also understand that if I / we so desire, a general report of testing results will be provided to myself / ourselves by phone and that if I / we so desire I / we may request in writing that testing results be released to my / our child's school. Otherwise no individual results will be provided to my / our child's school. I/ we understand that a general report does not include scores or percentile rankings on any of the tests undertaken by my child but will be a summary of his/ her performance in each area of testing.

I / We understand that only group data will be reported to the school and in any published reports.

I / We understand that any raw data will be kept in a locked cabinet at the University of Calgary and destroyed three years after publication of these study results.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to (your child's) participation as a subject. In no way does this waive your legal rights nor release the investigators, sponsors or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for

clarification or new information throughout your participation. The investigator will ,as appropriate, explain to your child the research and his or her involvement, and will seek his or her ongoing cooperation throughout the project. (Parents or guardians must sign/cosign for their children.) If you have further questions concerning matters related to this research, please contact: Bradley Dye at 289-7946 or Dr. Marilyn Samuels at 220-8566

For parents whose children attend Capitol Hill Elementary or Dr. Oakley School, any complaints associated with this research should be directed to Linda Brost, Specialist, Accountability Services either in writing (E-mail LGBROST or fax 294-8434) or telephone 294 - 8447.

If you have any questions concerning the ethics review of this project, or the way you have been treated, you my also contact the office of the Vice President (research) and ask for Karen McDermid, 220-3381. If you have any concerns about the project itself, please contact the researcher.

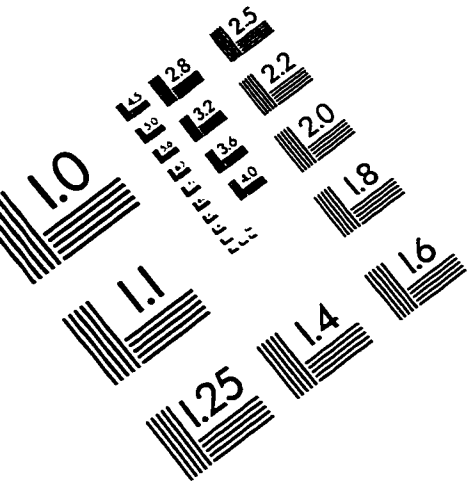
_____

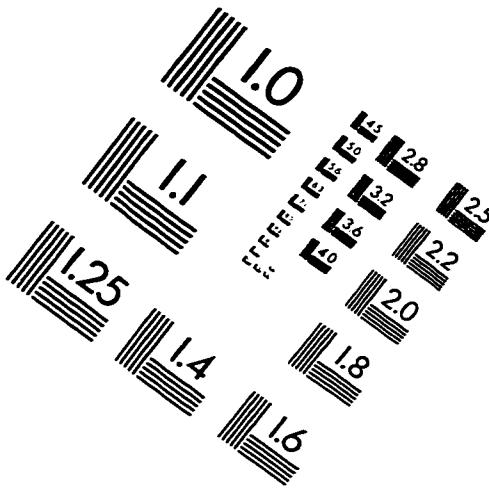
Signature of Parent /Guardian for participant

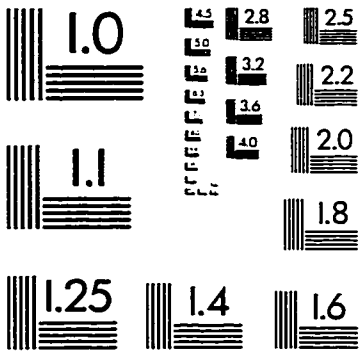
_____

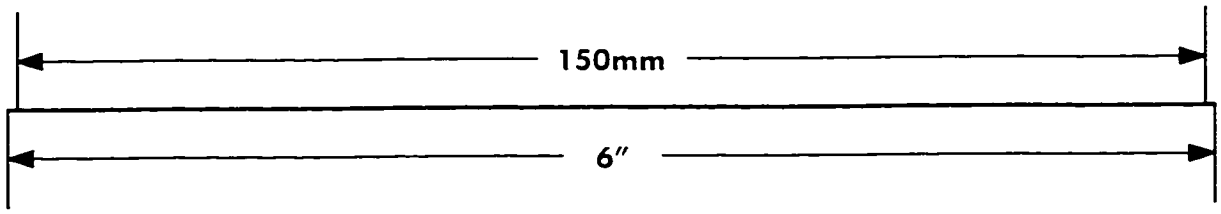
Date

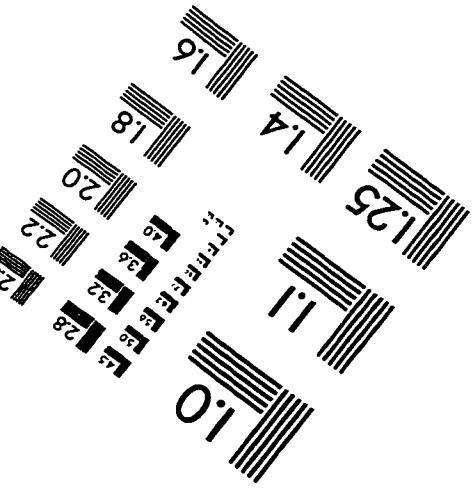
IMAGE EVALUATION
TEST TARGET (QA-3)

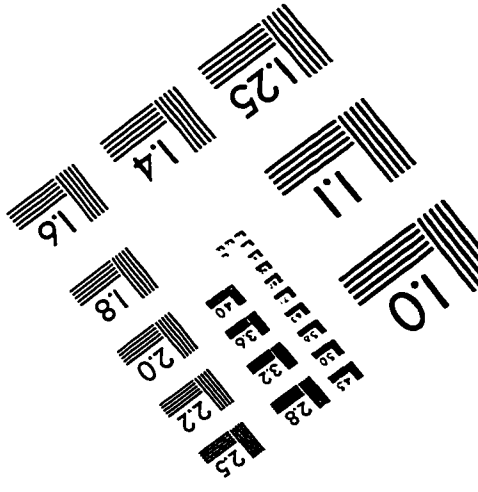












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