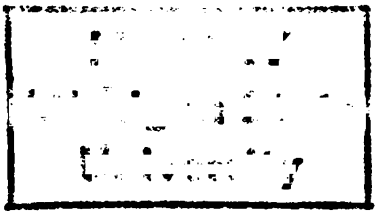

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ATTENTION DEFICIT DISORDER: INATTENTION, IMPULSIVITY OR BOTH?

By

Robert Wallace Hill

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ABSTRACT

ATTENTION DEFICIT DISORDER: INATTENTION, IMPULSIVITY OR BOTH?

By

Robert Wallace Hill

Children with Attention Deficit Disorder (ADD) were hypothesized to have differing manifestations of problems with inattention and impulsivity rather than the homogeneous experience of these symptoms that the DSM-III diagnosis of ADD describes. To test this hypothesis a computerized version of the Continuous Performance Task (CPT) was proposed as a measure of inattention (Omission errors) and impulsivity (Commission errors) and was found to differentiate ADD from normal children. CPT errors were used to separate ADD children into sub-groups depending upon the number of Omission versus Commission errors made. These groups were compared on other measures of inattention and impulsivity including the Matching Familiar Figures Test (MFFT), the Personality Inventory for Children (PIC) factor scales One and Four, and the SNAP Inattention and Impulsivity scales.

Identifying CPT Omission errors as an index specific to inattention and CPT Commission errors as an index specific to impulsivity was not well supported by this investigation.

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Introduction

During the past 15 years, substantial clinical and research interest has been focused on the childhood disorder that is generally termed hyperactivity. A principle motivation in the volume of research devoted to this syndrome is the fact that hyperactivity is the referral complaint most frequently encountered by psychological health care providers treating children (Rubinstein and Brown, 1984).

The latest DSM-III (1980) classification has relabeled hyperactivity as Attention Deficit Disorder (ADD), with or without Hyperactivity. The DSM-III diagnosis of ADD includes several subgroups of symptoms--attention deficit, impulsivity and hyperactivity--with hyperactivity not necessarily present. Investigators have identified problems with attention and impulsivity to be prevalent in samples of children designated as ADD. Although several researchers have suggested the likelihood of a more heterogeneous ADD population than the DSM-III diagnosis allows (Whalen and Henker, 1980; Weithorn, Kagen and Marcus, 1984; Brown, 1983), few studies have made an effort to differentiate subgroups of ADD children based on the differing manifestations of attention deficit and impulsivity.

There has been some question as to whether attention deficits are always accompanied by impulsivity within the

ADD syndrome (O'Dougherty et al., 1984; Brown, 1983). There may be some children labeled ADD who have attention deficits but who are not particularly impulsive and conversely, some children labeled ADD may be impulsive and not have attention deficits. Support for the co-occurrence of attention deficits and impulsivity has been offered by some investigators (Douglas, 1972; Edelbrock et al., 1984) while other investigators have found evidence against this relationship (Brown, 1983; Weithorn et al., 1984).

The differentiation between attention deficits and impulsivity in children labeled ADD (or hyperactive) would have a bearing on the type of problems children have academically, behaviorally and socially. Intervention strategies for attention deficits as opposed to problems with impulsivity could be more specific as could prognoses for future problems (Brown and Conrad, 1982). There may be a sub-group of children with attention deficits and little impulsivity, who have primary problems with learning and academic achievement but perhaps few conduct problems. There may also be a sub-group with little attention deficit but high impulsivity who have more primary conduct problems which lead to problems in school and perhaps secondary problems with academic achievement. Either sub-group might have difficulties with peers but perhaps for different reasons.

One test frequently used to measure sustained attention in research on both hyperactive and learning disabled

children is the Continuous Performance Test (CPT) (Rosvold et al., 1956; O'Dougherty et al., 1984). This task involves the random presentation of a series of visual stimuli at a fixed and rapid pace (typically one every 1 to 1.5 secs.). The child's task is to monitor the stimuli and respond whenever a predesignated target stimulus or sequence of stimuli appears (Rosvold et al., 1956). The common indices employed to measure sustained attention and impulsivity with the CPT include: target stimuli detected (hits), target stimuli missed (errors of omission), and responses to non-target stimuli (errors of commission) (Sykes, Douglas and Morganstern, 1973). Errors of omission can be considered an index of sustained attention and errors of commission can be considered an index of impulsivity (Levy, 1980).

This study seeks to assess a sample of children diagnosed as having ADD for individual differences in the manifestation of attention deficits and impulsivity. The first question that this investigation addresses is the ability of a version of the CPT to discriminate children diagnosed ADD from normal children. The second question addressed in this investigation concerns the hypothesis that the population of ADD children exhibits a heterogeneous manifestation of attention deficits and impulsivity as differentiated by the CPT. After identifying a sample of ADD subjects, the sample will be divided into the following three groups on the basis of CPT scores: (1) children with

high omission scores but low commission scores; (2) children with high commission scores but low omission scores; and (3) children who have roughly equivalent omission and commission scores. These three groups are hypothesized to represent, respectively, ADD children with: 1) a high attention deficit but low impulsivity, 2) high impulsivity but low attention deficit, 3) roughly equivalent problems with attention and impulsivity.

The investigation will seek some confirmation for differentiating ADD children into these groups by using several other measures which are good indicators of impulsivity, inattention, and conduct problems. Other measures could provide some convergent validity to the hypothesized division of ADD children into sub-groups by corroborating the differing manifestations of inattention or impulsivity found with the CPT. Children with primary attention deficits who are not impulsive (group 1) may have primary problems with academic achievement, but only secondary conduct problems. Children with high impulsivity but low attention deficit (group 2) may have more primary conduct problems than group 1 children, and have secondary problems with academic achievement. This study will seek to differentiate the kinds of problems ADD children experience as a consequence of different deficits with attention and impulsivity. The heterogeneity of these symptoms found in ADD children may explain more about their differing problems than has been previously recognized.

Review of Literature

Hyperactivity in children had been reported as early as the beginning of this century, although the problem has been given a number of different labels. During the past 80 years, the disorder has been variously labeled "organic driveness," "postencephalitic behavior disorder," "restlessness," "fidgety phils," "conduct disorder," "brain-injured child," "minimal brain dysfunction" and "hyperkinesis" (Barkley, 1981). In this review the term hyperactivity will be used interchangeably with Attention Deficit Disorder (ADD), in keeping with much of the current literature. The earliest reports described restlessness, impulsivity, poor concentration and overactivity in groups of retarded or severely neurologically impaired children. These behaviors were described as secondary to obvious injuries, neurological trauma or diseases experienced by the children (Barkley, 1981). Later investigators were influenced by these reports which suggest that since these behaviors followed brain injuries, then any child showing such hyperactive behaviors must also be brain injured. This assumption led to the suspicion of "soft" or undetectable neurological dysfunctions as the cause of hyperactivity. However, Rutter (1977) observed that most children suffering from brain injuries do not develop hyperactivity and that less than five percent of hyperactive children show any hard evidence of structural brain damage, thus weakening the argument for a connection between hyperactivity and brain

damage.

Later research efforts on hyperactivity have focused on overactivity, inattention, non-compliance, conduct problems and negative peer interactions (Barkley, 1981). Varying approaches to the definition of hyperactivity lead to difficulty in determining the incidence of the disorder. Werry and Quay (1971) surveyed teacher ratings for a large population of school children and found that thirty percent of boys and twelve percent of girls were rated overactive, 46% of boys and 22% of girls were judged disruptive and 43% of boys and 25% of girls had short attention spans. These data give some indication of the need for a more specific criteria for defining hyperactivity. Investigating a more stringent approach to studying the prevalence of hyperactivity, Lambert, Sandoval and Sassone (1978) determined what percentage of children was called hyperactive by physicians, by teachers and by parents. If the opinion of only one of these sources was used as the criterion, then five percent of school children were called hyperactive. If consensus of all three observers was required for diagnosis, then only one percent of the children were labeled hyperactive. This finding suggests that, aside from choosing a group of symptoms to make the diagnosis for hyperactivity, having agreement between more than one observer provides a much more stringent method for diagnosis.

Current research on prevalence indicates that

approximately three to five percent of school-age children are hyperactive (Barkley, 1981), although estimates vary according to the definition used and the stringency of the diagnostic procedure. Trites (1979) found a relationship between socioeconomic status (SES) and hyperactivity, with the incidence and severity of symptoms increasing as SES level decreased. Prevalence rates also differ according to the sex of the child. Ratios have been reported from 3:1 to 9:1 in favor of males (Whalen and Henker, 1980). Various hypotheses have been advanced to explain the sex and SES differences in prevalence, with cultural influence prominent on the list, but no single explanation has been found sufficient to account for these differences.

ADD children manifest different problems at different developmental stages with much individual variation. Barkley (1981) cites Ross and Ross (1976) in describing the developmental diagnosis of hyperactive children, which is summarized below. Parents are most likely to report on onset of problems at age two or three, especially for problems of non-compliance to parental requests, restlessness and a tendency toward accidents. When ADD children reach school age, social conduct problems become progressively more severe, including poor peer interactions and non-compliance in public. The child may seem unresponsive to typical disciplinary methods, and may become angry and possibly prone to tantrums. Aggression toward other children is often seen with hyperactive children, as

is selfishness and a reluctance to accept responsibility for their behavior. They are often inadvertently destructive, more through impulsivity and clumsiness than through anger. ADD children seem immature and often perform poorly academically. By second grade, they are often suspected of having a learning disability, which school staff may attribute to behavior problems rather than a cognitive deficit. Because such children are gaining a reputation for immature, selfish, aggressive, overactive behavior and poor athletic ability, they may be ostracized by their peers. Their academic performance is generally poor over time so that, as ADD children become older, they often exhibit poor self-esteem and depression as a result. Acting out behavior may increase as a response to the chronic failure and social isolation that these children experience. Truancy and juvenile delinquency are not uncommon in later childhood years (Weiss, Hechtman and Perlman, 1978).

Primary Symptomatology

One of the primary symptoms recognized in hyperactive children is inattentiveness. Children may fail to detect stimuli to which they are asked to attend, they may have trouble organizing the appropriate response to stimuli, or they may respond to the wrong aspects of the stimulus. A particular problem for ADD children is believed to be in sustaining attention to task stimuli while inhibiting responses to stimuli irrelevant to the task.

Parents will often find an ADD child inattentive in that he or she may not listen to directions given, not complete assigned chores, not complete homework assignments, and have trouble playing alone for prolonged periods (Barkley, 1981). At school, ADD children manifest inattention by being easily distracted from assigned tasks, by not listening to the teacher or not remembering directions and by frequently shifting focus of eye contact to off-task stimuli (Kupietz and Richardson, 1978).

Impulsivity, or a failure to inhibit responses, is also considered a primary feature of hyperactivity. Such children tend to respond rapidly to tasks, often before thinking through their response. Impulsive responding overlooks the consequences of behavior and generally yields more mistakes in classroom settings. Hyperactive children often get themselves in more risky situations and are more likely to respond aggressively (both verbally and physically) when frustrated or hurt by others without considering the consequences of their actions. Impulsive responding leads the child to be perceived as socially immature and to be censured and punished more frequently than normal children (Klein and Young, 1979; Barkley, 1981).

Overactivity has long been considered one of the primary features of hyperactivity, although this symptom has been established less reliably than inattentiveness and impulsivity. A variety of techniques and observational

methods have been applied to measure the activity level of hyperactive children compared to normals. Findings generally indicate that restlessness and task-irrelevant activity increase for hyperactive children when the situation and concentration required is more restrictive (Barkley, 1981). In a situation which demands sustained attention and inhibited activity, such as a classroom, hyperactive children are observed to move about in their seats, leave their seats, manipulate objects that are irrelevant to the assigned task and generally behave more restlessly than normal children (Klein and Young, 1979). There is disagreement as to whether overactivity is a symptom experienced by all ADD children. As mentioned earlier, the current DSM-III diagnosis includes hyperactivity as an optional concomitant symptom, not required for the diagnosis of attention deficit disorder.

The three primary symptoms of inattention, impulsivity and overactivity have been extensively investigated in samples of ADD children. They have been correlated with a variety of measures and results suggest that these three symptoms are not strongly related to each other (Weithorn et al., 1984; Whalen and Henker, 1980; Barkley, 1981). From these studies, one can conclude that the population of hyperactive children is composed of a heterogeneous group, some children being more inattentive, others being more impulsive, some being more overactive, and still others having a combination of symptoms.

Secondary Symptomatology

ADD children often exhibit other problems which may be related to, or simply co-exist with, the more primary features. One such secondary symptom observed frequently in ADD children is aggression. Lahey et al. (1980) found that ratings on hyperactivity and conduct problems scales were significantly correlated. Loney (1978) observed that while aggression and hyperactivity are often seen together, they do not correlate well, so that if a child exhibits more intense ADD symptoms, he or she will not necessarily be more aggressive. However, aggression does help predict later social adjustment.

August, Stewart and Holmes (1983) reported on a four-year follow-up of two groups of hyperactive boys, one group with associated conduct problems and the second group "purely" hyperactive. Boys originally diagnosed as purely hyperactive showed few antisocial or aggressive behaviors at follow-up, while boys who were originally diagnosed both hyperactive and conduct- disordered were reported to be aggressive, non-compliant, egocentric, exhibiting antisocial behavior and using alcohol. Both groups continued to be inattentive and impulsive (the mean age at follow-up was 14.2 years).

Another secondary symptom is that ADD children often have difficulties with academic achievement. As noted above, hyperactive children display frequent

inattentiveness and off- task behavior in the classroom, which likely contributes to academic problems. Barkley (1981) reports that as many as 60% to 80% of hyperactive children are believed to have learning disabilities, defined as a significant deficit compared to expected grade level in one or more subject areas, given normal intelligence and educational opportunities. He estimates the risk of school failure to be two to three times higher in hyperactive than in normal children, with many hyperactive children being retained at least one grade.

ADD children also have trouble with social relationships, often with peers, teachers and parents. They appear to be more disruptive, intense, negative, non-compliant and impulsive than normal children, which leads teachers and parents to exercise more supervision and discipline than same-age normal children require (Barkley, 1981; Whalen and Henker, 1980). This causes some consternation for caretaking adults and also for peers, who are often put off by the immaturity, selfishness and lack of concern for others that ADD children frequently display. The consequent alienation that ADD children often experience has the effect of diminishing self-esteem. Waddell (1984) reported on 30 adolescents (mean age 14.5 years) who had been diagnosed as hyperactive in early childhood. These children were less socialized and less resourceful, and had less confidence in themselves, less self-discipline and fewer interpersonal interactions than

their peers. They were more likely to describe themselves as inadequate, to be dissatisfied with their own behavior and to be dissatisfied with relationships.

ADD children do not uniformly experience all of the symptoms and problems mentioned; there are many individual differences between children. This heterogeneity within the ADD population is exhibited in differing severity in the manifestations of symptoms. Some studies have attempted to differentiate ADD samples on the basis of particular symptoms. A number of investigations have sought to establish a distinct subgroup of ADD children with learning disabilities (Halperin, Gittelman, Klein and Rudel, 1984; Dykman, Ackerman and Oglesby, 1979). Others have attempted to differentiate subgroups on the basis of physiological arousal (Zentall, 1975; Rosenthal and Allen, 1978), and some have attempted to distinguish varying groups of ADD children on the basis of overactivity (Maurer and Stewart, 1980; Lahey, Schangheny, Strauss and Frame, 1984). These differing attempts to distinguish subgroups among the ADD population have varied in their success, but there is no clear agreement about the nature of the heterogeneity in hyperactive children.

The proposed study seeks to differentiate subgroups of ADD children on the basis of differing manifestations of inattention and impulsivity using the Continuous Performance Test (CPT). Differing degrees of problems with these primary symptoms may be reflected in differing

manifestations of secondary symptoms as well. Particulary inattentive ADD children may have more academic achievement problems, possibly learning disabilities. Particulary impulsive ADD children may exhibit more conduct problems, more disruptive behavior and may experience more social maladjustment. These primary symptoms can be differentiated using the CPT, and then correlated with other secondary problems.

Assessing Attention and Impulsivity

As indicated in the criteria for the current DSM-III diagnosis, and the change from labeling the disorder Hyperkinesis to naming it Attention Deficit Disorder, research efforts on diagnosing and treating hyperactivity have come to focus on problems with attention and impulsivity. Sykes, Douglas, Weiss and Minde (1971) produced a pivotal study in this shift in emphasis from overactivity to attention. A sample of hyperactive children was compared to a matched group of controls on a vigilance task, a version of the Continuous Performance Test (CPT). The hyperactive children performed dramatically worse than the controls despite their similarity in age and IQ. This study and a later one by the same group (Sykes, Douglas and Morganstern, 1972) were influential in highlighting attention deficits as a significant component of the hyperactive syndrome (Aman, 1984). This study was also one of the first to utilize the CPT on a sample of

hyperactive children (Levy, 1980).

The CPT provides a basic paradigm for studying sustained attention as a behavioral process. It was first described by Rosvold, Mirsky, Saranson, Bransome, and Beck (1956) as an instrument designed to require a high level of continuous attention over time, which discriminated brain damaged children and adults from normals. It is a vigilance task, incorporating elements of stimulus selection, sustained attention and inhibition of irrelevant responses (Levy, 1980).

Deficits shown by ADD children on the CPT have been encountered repeatedly. ADD children typically identify fewer targets (errors of omission), respond more frequently to non- target stimuli (errors of commission), show a greater decrease in target detection over time, and may become more restless and commit even more impulsive errors as time on the task increases (O'Dougherty et al., 1984; Douglas, 1972; Klorman et al., 1979; Kupietz, 1976; Sykes et al., 1973). Investigators have found the CPT to be a good empirical assessment instrument which has emphasized the attention deficit of hyperactive children (Aman, 1984). The CPT has been shown to be useful in measuring the change in performance of ADD children receiving stimulant medication (usually methylphenidate) (Sykes et al., 1971; Kupietz and Balka, 1975; Sostek, Buschbaum & Rapoport, 1980). Stimulant medication has often been found to improve the vigilance performance of ADD children.

The CPT has been shown to be sensitive to age, at least with young children. Levy (1980) administered the CPT to 230 normal, 3 to 7 year old school children in Sydney, Australia, deriving some developmental age norms for the instrument. Levy found that more than 50% of children less than four years old were unable to complete the CPT, and all children older than 4.5 years could complete the task. O'Dougherty, et al. (1984), observed that age differences in subject samples might have an important bearing on the comparison of CPT results. Visual CPT tasks require some skill in discriminating letters, such that older children might have some advantage in making the differentiation between letters. This age effect would be most important to consider with a young age sample.

The stimuli presented in the CPT generally consist of five to ten letters, with one letter, usually "X", designated as the target. The letters are randomly ordered except that the target stimulus will appear a certain percentage of the time. Generally 10% to 20% of stimuli are targets (Kupietz and Balka, 1976; Klee and Garfinkel, 1983).

The CPT may be administered in a variety of ways. The task typically involves the quasi-random presentation of a series of visual or auditory stimuli at a fixed pace, typically one every 1 to 2 secs, with brief exposure times, generally between 100 and 500 ms. Variations in administration involve the means of presentation of

stimuli, the size of the stimulus presented, the pace of the stimuli, and the exposure time. The means of presentation utilized by different investigators has included slide projector (O'Dougherty et al., 1984), video tape recorder in combination with television monitor (Levy, 1980; Sergeant and Scholten, 1985), and computer in combination with display monitor (Klee and Garfinkel, 1983).

An important concern when administering the CPT is the length and the rate of stimulus presentations. Investigators administering a visual CPT on samples of hyperactive children have used stimulus lengths and rates varying from 50ms every 1.4s (O'Dougherty et al, 1984) to 2s every 3.5s (Levy, 1980). An obvious consideration in choosing stimulus length and rate is to pace the presentation so that the child has sufficient time to perceive and respond, but not so much time as to allow the child to divert attention from the task without the danger of missing target stimuli. The test could be a more demanding perceptual task at a fast pace and more of a test of concentration at a slow pace. Regardless of pace the CPT provides a test of sustained attention or vigilance over time. As the CPT proves itself useful in diagnosing and researching ADD, continuing research on stimulus presentation timing would further standardize the measure.

With the recent availability of micro computer technology, the use of a computer to administer the CPT has

several advantages. First, the display time and interval can be chosen and programmed to provide an accurate and constant rate of presentation. Second, the child's responses can be accurately recorded and stored on magnetic media for analysis. Third, once programmed, the computer provides a nearly automated, and highly accurate, means of measuring and recording vigilance performance.

For the proposed study the computerized CPT can provide an objective way to differentiate ADD children on the basis of differing deficits with attention and impulsivity. Those children who have a more distinct problem with inattention but not with impulsivity can be differentiated using CPT scores (high omission, low commission errors) from children who have a more distinct problem with impulsivity but not inattention (high commission, low omission errors). A third group would consist of children having roughly equivalent problems with inattention and impulsivity (no differences in the number of omission and commission errors). The CPT has proved a reliable diagnostic instrument for differentiating ADD children from normal children and the computerized version makes such testing particularly efficient. Further differentiating children on the basis of the kind of deficit they exhibit (inattentive, impulsive or both) can provide a means to investigate more specific problems associated with differing primary symptoms.

Another measure of impulsivity often used in

studies of hyperactivity is the Matching Familiar Figures Test (MFFT) (Kagen, 1964). Different forms of the MFFT are available for preschoolers, school-age children and adults. The test format involves the simultaneous presentation of a figure (e.g., a boat, an animal, a telephone), with four, six or eight facsimiles differing in one or more details. The subject is asked to choose the alternative which exactly matches the standard figure. The amount of time taken for the first response (latency) and number of errors overall are recorded for each of the 12 sets of figures. For any sample of subjects, a child who scores below the sample median on MFFT response time and above the median on errors is considered impulsive; a child who scores above the median on response time and below the median on errors is considered reflective (Kagan et al., 1964; Messer, 1976). The impulsive child is presumed to respond rapidly and give less consideration to response accuracy than the reflective child who pauses to think and is concerned about the accuracy of his or her responses.

Several investigators have observed a methodological problem in the use of median splits for separating samples of children on the basis of MFFT error and latency scores (Bentler, and McClain, 1976; Block et al., 1974; Messer, 1976). The standard response to avoid this problem has been to compute an impulsivity- reflectivity index by transforming and combining error and latency scores which creates a standardized reference of impulsivity for the

sample (Weithorn et al., 1984). This procedure avoids any loss of power in discriminating between impulsive and reflective tendencies, as well as avoiding artificial dichotomies.

As a cognitive-perceptual task, the MFFT provides a good measure of impulsivity through the reflection-impulsivity index. The MFFT would provide a means of corroborating the distinctions made by the CPT by identifying particularly impulsive children within a sample of ADD children. The ADD children who fall into group Two according to their CPT scores (low omission errors, high commission errors), indicating high impulsivity, should also score high on the MFFT Impulsivity-Reflectivity index relative to CPT groups One and Three.

A different measure of impulsivity can be derived from the Personality Inventory for Children (PIC) (Wirt, et al.,1984). The PIC is a behavior rating scale, completed by a child's parent or guardian, which is designed to provide clinically relevant descriptions of the child's behavior, affect, cognitive status, and family characteristics.

The results from administering the PIC are plotted on a profile graph which indicates clinical and factor scale scores relative to standardized normal scores. Interpretations provided by Lachar (1975) are based on how far the score falls above the mean standard score of 50. For scores on the Acting Out/Poor Self Control Factor which

fall between a T-score of 70 to 79, the following interpretation is given:

> Parents and teachers are likely to find this child's behavior problematic. Impulsivity, distractibility and an inability to conform to limits are frequently characteristic. Similar children often argue and talk back to adults. They frequently disturb classmates by teasing, interrupting, provoking fights, and other attention seeking manuevers (Lachar, 1975, p. 24).

For children whose factor 1 scores fall above a T-score of 80, a more serious interpretation is often appropriate:

> A disregard for rules and societal expectations at home and at school is likely. Associated symptoms often include lying, stealing, arguementativeness, labile affect, irritability, limited frustration tolerance, and temper outbursts. Current behavior is likely to reflect impulsivity, poor judgement and an impaired interpersonal adjustment ... Similar children may have difficulty achieving in school which may be related to behavior suggestive of distractibility and overactivity (Lachar, 1975, p. 24)

The PIC provides a measure of impulsive behavior from a different perspective than the MFFT, namely that of the mother of the child. Performance on the PIC Acting Out factor scale is a measure of impulsive behavior as observed by the mother. This separate source of measure will provide convergent validation of other measures of impulsivity used in this investigation. The PIC factor scale provides another means of checking the division of the ADD sample on the basis of inattention and impulsivity. Those children who fall into Group 2 (low omission errors, high commission errors), indicating high impulsivity, should also show a higher score on the Acting Out factor scale on the PIC than children who fall into the other two

groups.

If this hypothesis is borne out in the results then it will provide further evidence for the importance of recognizing heterogeneity among the ADD population. Children who have a particularly impulsive pattern of behavior often do have problems in school which lead to a deficit in academic progress. This impulsive behavior can occur independently of any attention deficit yet many children who display impulsive or acting out behavior may be referred to health practitioners and often labeled hyperactive. This pattern of impulsive behavior leading to possible academic difficulty due to conduct problems needs to be differentiated from a pattern of academic difficulty and possible conduct problems due to actual attention deficit.

Another recently developed measure used to identify children for the ADD diagnosis is the SNAP (Stephens, Pelham and Skinner, 1984; Swanson, Nolan and Pelham, unpublished manuscript). The SNAP is an attempt to provide a behavior rating scale which directly assesses the presence of ADD symptoms as defined by DSM- III. It was designed as a short screening measure (23 items) for ADD and addresses the four most pertinent factors associated with ADD: inattention, impulsivity, hyperactivity, and peer interactions. The SNAP is completed by a parent (or teacher), who checks whether items apply "not at all," "just a little," pretty much," or "very much." The item

scores which comprise the four factors are simply summed, giving an indication of the prevalence of behaviors that make up the ADD diagnosis.

The SNAP is attractive for its simplicity, and because it provides a separate measure of the factors that are most pertinent in this investigation: inattention and impulsivity. Those who fall into Group One on the basis of CPT scores (high omission, low commission errors), indicating inattention but not impulsivity, should score high on the SNAP Inattention scale. Those who fall into Group Two on the basis of CPT scores (high commission, low omission errors) indicating impulsivity but not inattention should score high on the SNAP Impulsivity scale. Those who fall into group Three on the basis of CPT scores (approximately equivalent omission and commission scores) should also have approximately equivalent scores on the Inattention and Impulsivity scales of the SNAP.

Hypotheses

1) Given that the primary symptomatology of attention deficit disorder includes difficulty sustaining attention and inhibiting impulsive responding, it is hypothesized that the computerized CPT used in this investigation will differentiate ADD children from normal children.

2) Given the acknowledged heterogeneity of children classified as having attention deficit disorder, it is hypothesized that three sub-groups of ADD children can be

identified on the basis of their CPT error scores: a) Group One -- inattentive but not particularly impulsive (high omission, low commission errors); b) Group Two -- impulsive but not particularly inattentive (high commission, low omission errors); c) Group Three -- approximately equivalent difficulty with inattention and impulsivity (approximately equivalent omission and commission errors).

3) It is further hypothesized that Group One will represent ADD children with attention problems but little impulse control problems. This group is hypothesized to show chronic inattention problems at school and at home, but little disruptive, acting-out behavior. Consequently, this group will show low scores on the MFFT Impulsivity-Reflectivity Index, low scores on the PIC Acting Out scale, high scores on the SNAP Inattention scale and low scores on the SNAP Impulsivity scale.

4) It is further hypothesized that Group Two will represent ADD children who have problems with impulse control but little difficulty with attention. This group is hypothesized to have problems related to impulse control at school and at home such as disruptive behavior and conduct problems, but not to have problems related to inattention. Consequently this group is will show high scores on the MFFT Impulsivity-Reflectivity Index, high scores on the PIC Acting Out scale, low scores on the SNAP Inattention scale, and high scores on the SNAP Impulsivity scale.

5) It is finally hypothesized that Group Three will

represent children who have roughly equivalent problems with inattention and impulse control. Hence, this group will score high on any or all of the measures used in this investigation.

Method

Subjects

The subjects were 113 school-age children who were assessed for the Child Behavior Project, a treatment program for hyperactive children at Michigan State University's Psychological Clinic. Criteria for inclusion in the present study were: (1) age between 7 and 11 years; (2) a score of 15 or more (two or more standard deviations above published means) on the Hyperactivity Index of both the Conner's Parent and Teacher Questionnaires; (3) the absence of gross physical impairments, intellectual deficits or psychosis in either the child or parents; and (4) the child was not receiving medication for control of his or her hyperactivity.

On the basis of these criteria, 83 males and 30 females were included in the study. A group of 36 control subjects were also included, who were not significantly different from the ADD subjects in age, IQ, and grade level. These control subjects (24 boys, 12 girls) received scores on the Hyperactivity Index of the Conner's Parent Questionnaire that were clearly in the normal range (mean score for boys= 4.63, SD= 3.93; mean score for girls= 3.24, SD=3.25).

Subject Characteristics

	ADD Sample		Controls	
	mean	SD	mean	SD
Age (in years)	8.2	1.3	8.2	1.5
Grade level	2.6	1.4	2.7	1.4
Peabody Picture Vocabulary (standardized)	100.5	16.8	109.7	16.9
Conners Hyperactivity Score (Mother report)	19.2	6.0	4.2	3.7
Number of Males	83		24	
Number of Females	30		12	

General Design

The 113 hyperactive subjects were selected from children whose parents contacted the MSU Psychological Clinic because of the child's behavior problems in the home and/or at school. Many had been referred by health professionals in the community, and some had seen or heard a public service announcement about the program on television or radio.

Contact with parents was initially made by telephone to explain the project and to determine whether the program might be appropriate for the child. If the clinician did not feel that the child could benefit from the program a referral was made to more appropriate services. If the child appeared to be eligible, and the family agreed that the program could be beneficial, an appointment was made for a full assessment. The parent questionnaires were mailed to the parents for completion at this time, to be

returned on the day of the assessment.

Each child was seen at the MSU Psychological Clinic for a three-hour session during which a series of measures were administered, including the ones being used in this study. Control subjects were assessed in the same manner as ADD subjects, with the examiners unaware whether they were testing normal or ADD subjects. If the child was eligible for the program on the basis of the assessments, then the child's school teacher was contacted and asked if he or she would be willing to fill out a behavioral questionnaire. The Conner's Teacher Rating Scale was mailed to the school, filled out by the teacher, and returned to the clinic by preaddressed, stamped envelope.

Measures

Matching Familiar Figures Test (MFFT) The MFFT (Kagan,1965) consists of 12 tasks. Each task contains a stimulus picture and a separate array of six pictures, one of which is identical to, and five of which are variants of, the stimulus picture. The child is required to choose the identical picture. Errors in selection, as well as the time it takes to make the first response (latency), are recorded for each of the twelve tasks. Both error and latency scores have been found to be associated with impulsivity in hyperactive children (Weithorn, Kagen and Marcus, 1984). Children with an impulsive cognitive style have shorter latencies and more errors than children with

reflective cognitive styles.

Stability of the MFFT was tested with 104 children at a one-year interval. Correlations for latencies on the first and second administrations were high (mean= .62). Response latencies were also highly correlated to response latencies on other visual matching tasks (median = .64) (Kagan, 1965). Short term test-retest reliability was tested by Egeland (1974), who divided the 12-item MFFT forms for children and adults into three eight-item forms. Correlations among the three tests ranged from .92 to .98. Glow et al. (1981) found the MFFT to yield internally consistent, stable, reliable measures of latencies, errors and Reflectiveness-Impulsiveness.

As discussed above, in order to avoid problems associated with median splits a composite variable was created, the Impulsivity-Reflectivity Index. Errors and latencies were transformed into T scores and the distribution of these standard scores for latencies was inverted (so that higher scores signify shorter latencies). Standard scores for errors and latencies were then added together to form an Impulsivity-Reflectivity Index (Weithorn, Kagen and Marcus, 1984).

Revised Conner's Parent and Teacher Rating Scales (Abbreviated Version) These scales were designed to identify hyperactive children and to evaluate the effectiveness of treatment (Conners,1969). This

questionnaire has been used extensively with school-age children and has proved a reliable means of differentiating hyperactive and normal children (Sprague, Christensen and Werry, 1974; Sandoval, 1977). Test- retest reliabilities of the questionnaires range from .70 to .90 (Goyette et al., 1978; Conners, 1973). Two studies have provided concurrent validity for the Conners scales, supporting both clinical and experimental applications (Zentall and Barach, 1979; Lahey, Green and Forehand, 1980). An abbreviated Parent-Teacher Questionnaire has been prepared (Conners, 1973) which consists of ten overlapping parent and teacher items. Correlations between the abbreviated questionnaire and the full parent and teacher questionnaires have been reported at .94 and .92 (Werry et al., 1975). Mother-father and parent-teacher correlations have been reported acceptable at .55 and .49 respectively (Goyette et al., 1978).

Personality Inventory for Children--Revised (PIC) The PIC is a multidimensional personality instrument designed to provide assessment and screening information for children ages 6 to 16 (Wirt et al., 1977). The long version (600 items) and short version (280 items) consist of true-false statements, such as "my child has many friends" and "my child often has nightmares," which are answered by a parent or other caretaker. Three validity scales, the Adjustment scale, and 12 clinical scales can be

plotted on a profile sheet converting raw scores to T scores. The 12 clinical scales are: Achievement, Intellectual Screening, Development, Somatic Concern, Depression, Family Relations, Delinquency, Withdrawal, Anxiety, Psychosis, Hyperactivity, and Social Skills. The PIC was standardized on 2390 children (equal number of boys and girls) (Wirt et al., 1977).

A factor analysis of the PIC items was conducted by Lachar (1975) and revealed five factor scales with significant loadings. One of the factors (factor 1), accounting for 49% of the common variance, is variously named Acting Out, Undisciplined, or Poor Self Control. The clinical scales which contribute the most to this factor are: Delinquency, Adolescent Maladjustment, Asocial Behavior, Externalization and Delinquency Prediction. This factor scale is an indication of impulsivity which could be used to possibly corroborate the impulsivity scores from the CPT.

A second factor scale (factor 4), labeled Cognitive Development, accounted for 19% of the common variance. The clinical scales which contributed most to this factor include: Development, Achievement, Intellectual Screening, Learning Disability Prediction and Ego Strength. This factor scale is a measure of age-appropriate academic achievement and is sensitive to problems with attention and concentration (Lachar, 1975). High scores on the Cognitive Development factor scale could be used to corroborate

inattention scores from the CPT.

SNAP Checklist The SNAP Checklist is a teacher-parent checklist consisting of the operational criteria for diagnosing attention deficit disorder according to DSM-III (1980). It was developed recently as an instrument specifically designed to diagnose ADD with or without Hyperactivity (Swanson, Nolan and Pelham, unpublished manuscript). The SNAP consists of 23 items such as "Often doesn't seem to listen" and "Often acts before thinking" which are scored on a four-point scale from "not at all" to "very much." The SNAP items are grouped into four categories: Inattention, Impulsivity, Hyperactivity and Peer Interactions, consonant with the symptoms that the items refer to.

Because the SNAP is a relatively new instrument, reliability and validity data are sparse. Scores for a normal elementary school sample of 610 children are available along with some criteria for using the SNAP to diagnose ADD with or without Hyperactivity (Swanson, Nolan, and Pelham, unpublished manuscript). The same investigators assessed the validity of the SNAP against the Conners' Scales and found total score correlations from .76 to .94. They found test-retest reliability for mothers retested at a 6-week interval to be .78.

Continuous Performance Test The CPT was administered using an Apple IIe micro-computer with a custom-made program (Conners, 1980) to present stimuli on a monitor screen. Two versions of the CPT were administered, the "X" and the "B-X." For the "X" version, the program presented the stimulus X, 50 times, randomly interspersed among twenty other alphabetic characters. No character was presented twice in a row. The characters were 10 cm high and each stimulus was presented for 200 ms, with an interval of approximately 1.2 secs between stimuli. For the "B-X" version, the "B-X" sequence was presented 50 times, randomly interspersed among five alphabetic characters, with the presentation and interval times the same as the "X" version. The subjects responded by pressing a hand-held paddle button, with responses scored by the computer. Correct responses to targets (hits), errors of omission (targets missed) and errors of commission (responses to non-targets) were recorded.

The CPT has been found to be reliable after a two-week retest (Sykes, Douglas and Morgenstern, 1973), and was found a valid means of discriminating ADD from normal children (Klee and Garfinkel, 1983; O'Dougherty, Nuechterlein, and Drew, 1984).

Procedure

The CPT was administered individually by a research assistant (either a graduate or undergraduate student of psychology) who was trained to follow a standard set of instructions. The experimenters were blind to subject status (i.e., ADD or control) and were unaware of the hypotheses under investigation.

The experimenter led the subjects into an office where the micro-computer was located and entered the child's name into the computer program, which initiated the instruction phase of the program. The program greeted the child by name, demonstrated the use of the paddle button by directed practice, and gave instructions for the task (to push the paddle button every time the letter X appeared). After checking that the instructions were understood, ten practice trials were administered, with the experimenter saying "good" for correct responses and "no, that wasn't an X" for incorrect responses. When the child demonstrated an understanding of the task by completing the practice trials appropriately, then the "X" version was administered by the computer (if not, more practice trials were given until the child demonstrated understanding of the task).

The "B-X" version was administered following the "X" version with the instructions and practice trials similar to the "X" version except for the change in target. For the "B-X" version, the stimulus X is defined as a target only when it is preceded by the letter "B". This "B-X" version

is somewhat more difficult than the "X" version, requiring greater vigilance and inhibition of responses (Michael, Klorman, Salzman, Borgstedt and Dainer, 1981; Klee and Garfinkle, 1983).

The experimenter did not give any encouragement to pay attention during the test and ignored requests for attention from the child except to say: "I can't talk to you until you finish the test, please continue and we will talk later."

The MFFT was administered by a trained graduate or undergraduate student. The instructions were those developed by Kagan (1965). The examiner explained the task to the child and then administered practice sets, helping the child find the correct answer. The examiner then administered the six sets of figures, recording latency to the first response to the half- second, total number of errors for each set and the order in which the errors are made. When the subject chose correctly, the examiner praised the child. When the subject chose incorrectly, the examiner said "No, that is not the right one. Find the one that is just like this one (point)." Responses were recorded until the subject made the maximum six incorrect responses in one set, in which case the examiner showed the child the right answer.

Results

ANOVA Comparing ADD and Normal Children on CPT Scores

The first hypothesis addressed in these analyses was the ability of the computerized Continuous Performance Test (CPT) to differentiate ADD children from normal children. Mean scores for all measures are listed in Table I.

The distribution of the CPT error scores was skewed, with a large number of ADDs and Normals having low error scores and a smaller number of each group having high error scores. Consequently, a natural logarithmic transformation was applied to the CPT error scores in order to create a more symmetric distribution of scores.

Following the transformation of CPT error scores, analyses of variance (ANOVA) were performed using the CPT error scores to compare the two groups. Two sets of ANOVAs were performed, one for the X- Trial version of the CPT and one for the BX-Trial version of the CPT. The null hypotheses for the ANOVAs comparing the ADD and Normal groups were defined to be equal ADD and Normal population means on the CPT for Omission, Commission and Total Errors. The .05 significance level was selected for all tests. The results of these analyses are given in Table II.

For both CPT X-Trials and BX-Trials, ADD and Normal group means were significantly different for Total Errors, Omission and Commission errors with the exception of Commission errors for the CPT X-trials. The results

indicate that CPT error scores did differentiate ADD from normal children, although CPT X-Trial Commission error score differences only tended toward statistical significance ($F(1,147)=3.2$, $p=.08$). The null hypothesis, of no difference between ADD and Normal group means, was rejected.

ANOVA Comparing Sub-groups of ADD Children

After confirming that CPT error scores did differentiate ADD from Normal children acceptably, the ADD children were divided into three groups on the basis of their CPT X-trial Omission and Commission error scores. The ADD children were ranked according to their Omission and also their Commission scores so that those with the highest and lowest scores could be selected for their appropriate groups. Group One was defined as that 25% of the ADD sample with the highest omission but lowest commission scores ($n=27$), Group Two was defined as that 25% of the ADD sample with the highest commission but lowest omission scores ($n=28$), and Group Three consisted of the remaining ADD children who did not meet the criteria for Groups One or Two ($n=58$). The means for these CPT X-Trial sub-groups are presented in Table III. This procedure was repeated using the CPT BX-Trial error scores to provide a second set of data for analysis. The means for these CPT BX-Trial sub-groups are presented in Table IV.

Two sets of ANOVAs, one for the X-Trial and a second for the BX-Trial data, were performed for the three ADD

groups to detect any differences in ability to predict the following dependent measures of impulsivity and inattention: Matching Familiar Figures Test Impulsivity-Reflectivity Index (MFFTI-R), Matching Familiar Figures Test Total Errors, PIC Acting Out Factor scale score, PIC Cognitive/Learning Factor scale score, SNAP Inattention scale and the SNAP Impulsivity scale.

For the X-Trial analyses of variance only two of the dependent measures showed significant differences among the three group means. They were the MFFT Impulsivity-Reflectivity Index, $F(2,110)=3.84$, $p=.03$, and MFFT total Errors, $F(2,110)=7.14$, $p=.001$. For these two dependent measures post-hoc comparisons were made between the means for Groups One and Two. The two group means were not significantly different for either measure. There was a significant difference between groups One and Three and Two and Three on these measures which was not surprising given that groups One and Two were defined by having distinctly different CPT scores from group Three.

For the BX-Trial analyses of variance three of the dependent measures showed significant differences on the overall F-Test, the MFFT Impulsivity-Reflectivity, $F(2,106)=4.19$, $p=.02$, MFFT Total Errors, $F(2,106)=8.79$, $p=.000$, and the SNAP Inattention scale, $F(2,106)=7.08$, $p=.001$. Post-hoc comparisons of the means for Groups One and Two did not show a significant difference for any of these three dependent measures. The significant differences

again occurred between groups One and Three or Two and Three, which were not relevant to the hypotheses under investigation.

These analyses of variance were intended to test for differences in sub-groups of ADD children. Of particular interest were differences between Group One (high omission, low commission CPT errors) and Group Two (high commission, low omission CPT errors) on the dependent measures of impulsivity and inattention administered to the ADD sample. The ANOVA did not yield results supportive of the hypotheses under investigation. On the basis of these ANOVA results the null hypothesis of no significant difference between subgroups One and Two can not be rejected.

Regression Analyses

Regression analyses were undertaken to further investigate the role of CPT Omission versus Commission errors for ADD childrens' scores on the dependent measures of impulsivity and inattention. The rationale for using regression analyses was to gain some additional power by using the entire distribution of the CPT error scores to predict the dependent measures, and to provide additional information about the relative efficacy of the two types of CPT error scores in predicting the dependent measures. The regression analyses were done using two separate sets of CPT scores for X-Trials and BX-Trials. As with the analyses of variance, logarithmic transformations of the CPT error

scores were used.

The regression equations followed the same model for each of the six dependent variables whereby a constant, CPT Commission Errors, CPT Omission Errors and their interaction were used to predict each of the dependent variables in six separate equations. Also, a second equation was tested for each dependent variable to assess the effect of CPT Commission and Omission errors without their interaction. Thus, for each dependent variable the following two equations were tested:

Dep. Var. = Constant + Commission Errors + Omission Errors + Commission * Omission Errors

Dep. Var. = Constant + Commission Errors + Omission Errors

CPT X-Trial Regression Analyses

The regression equations using the CPT X-Trial error scores as independent variables indicated that the CPT errors were significant predictors for the following three dependent variables: MFFTI-R Index, MFFT Total Errors and the SNAP Impulsivity scale. These results are presented in Table V. CPT X-Trial error scores were not significant predictors for the other dependent measures. The results of each of the three regression equations with significant predictors is reported below.

MFFT Impulsivity-Reflectivity Index. For this dependent variable, the regression equation yielded both CPT Commission and Omission errors and their interaction as

significant predictors. When the interaction term was dropped only CPT Omission errors remained a significant predictor.

In an attempt to better determine the nature of the CPT Commission * Omission interaction, a spectrum of Commission and Omission values were inserted into the regression equation that was derived to predict MFFTI-R (see Table VI). For example, low Omission and low Commission error scores were put into the equation to produce a predicted MFFTI-R value of -1.27. A combination of high Omission and low Commission error scores (as obtained by children assigned to ADD Group One) produced a predicted MFFTI-R of 2.28. A combination of low Omission and high Commission error scores (as obtained by children assigned to ADD children assigned to Group Two) produced a predicted MFFTI-R of 1.16. This use of the regression equation provided further information about the nature of the interaction between Commission and Omission errors. Specifically, the results indicate that an ADD child with high Omission and low Commission scores on the CPT (as those assigned to Group Two) achieved a higher MFFTI-R score than an ADD child with low Omission and high Commission error scores (as those assigned to Group One). Yet a child with high Commission and high Omission error scores (as those assigned to Group Three) achieved a lower score on the MFFTI-R index than either of the other two high/low combinations (see Table VI.).

MFFT Total Errors. For this dependent variable, the regression equation indicated that CPT Omission errors and the interaction between Omission and Commission errors were significant predictors, while Commission errors tended toward significance, $T(3,109)=1.9$, $p=.058$. For the regression without the interaction term only CPT Omission errors proved a significant predictor. In order to investigate the nature of the interaction between Omission and Commission errors a spectrum of values were inserted into the regression equation derived to predict MFFT Total Errors, as with the previous dependent variable (see Table VI).

The pattern of MFFT Total Error values predicted from the different combinations of CPT Omission and Commission error scores is similar to the results obtained from predicting the MFFTI-R index. High CPT Omission combined with low Commission scores produced an MFFT Total Error score 1.5 standard deviations higher than the converse combination of low Omission and high Commission scores. High Omission and high Commission error scores produced the lowest expected MFFT Total Error score.

SNAP Impulsivity Scale. For this dependent variable, the regression equation indicated that CPT Omission errors and the interaction between Omission and Commission errors were significant predictors, while Commission errors were not a significant predictor. For the regression without the

interaction term none of the predictors proved significant. The regression equation value predicted from the high Omission, low Commission combination yielded a low fitted SNAP Impulsivity value of 5.9 (mean= 10.8, SD= 2.1). However the low Omission, high Commission combination yielded a high fitted value of 9.2.

In summary, the CPT X-Trial regression analyses indicate that CPT error scores account for a significant portion of the variance when predicting scores on MFFTI-R, MFFT Total Errors, and the SNAP Impulsivity scale. Often the interaction between Omission and Commission errors also provided for a significant portion of the variance. When looking at the relative effects of different combinations of Commission and Omission errors on the expected values of the dependent variables the following observations can be made: 1) for MFFTI-R and MFFT Total Errors the high Omission, low Commission combination (which represents ADD Group One, hypothesized as particularly Inattentive) produced the highest scores in both of these measures which were included as an index for impulsivity; 2) for the SNAP Impulsivity scale both Omission and Commission error scores appeared to have a roughly equivalent influence on this index of impulsivity, with the combination of high Omission, high Commission error scores producing the highest expected SNAP Impulsivity score.

CPT BX-Trial Regression Analyses

The CPT BX-Trial regression analyses yielded significant results when predicting the following dependent variables: MFFT Total Errors, the PIC Cognitive Development scale, the SNAP Inattention scale, and the SNAP Impulsivity scale. The results of these analyses are presented in Table VII. The results for each of these four regression equations are described below.

MFFT Total Errors. For this dependent variable, only CPT Omission Errors proved a significant predictor, and only without the Commission * Omission interaction in the equation.

When different combinations of Omission and Commission error scores were inserted into the regression equation, low Omission, high Commission errors produced a low MFFT Total error score (1 std. dev. below the mean). Other combinations were less distinctive, see Table VIII.

PIC Cognitive Development scale. For this dependent variable, both CPT Omission and Commission errors were significant predictors, but not their interaction. Without the interaction term in the regression equation only Omission errors remained a significant predictor. Manipulating different combinations of CPT Omission and Commission errors did not produce any expected PIC factor score notably different from the mean.

SNAP. When predicting both the SNAP Inattention scale and the SNAP Impulsivity scale, Omission errors, Commission

errors and their interaction proved significant predictors. Without the interaction term neither Omission nor Commission errors were significant predictors.

Inserting different combinations of values for Omission and Commission errors into the regressions equations for the SNAP Inattention or Impulsivity scales produced similar fitted values. The low Omission, high Commission combination produced the highest fitted values for the dependent variables (better than one Std. Dev. above the mean). However, the opposite combination of high Omission, low Commission produced only slightly lower fitted values in both of the dependent variables (see Table VIII).

In summary, the CPT BX-Trial regression analyses indicate that CPT error scores account for a significant portion of the variance when predicting scores on MFFT Total Errors, the PIC Cognitive Development Scale and the SNAP Inattention and Impulsivity scales. Again, the interaction between Omission and Commission errors was often a significant predictor. When examining the relative size of the expected dependent variable scores using different combinations of the Omission and Commission errors the following observations were made: 1) for the MFFT Total Errors score the low Omission, high Commission combination (representing ADD Group Two) produced a distinctly low score on this measure of impulsivity, while other combinations were less distinctive; 2) for the SNAP Inattention and Impulsivity scales, the converse combinations of high

Omission, low Commission and low Omission, high Commission error scores did not elicit notably different scores on either the Inattention or Impulsivity scales -- although both combinations produced high SNAP scale scores.

To summarize the results for all the analyses, the following conclusions are drawn: 1) the CPT error scores did distinguish the ADD children from normal controls; 2) dividing the ADD sample into subgroups on the basis of CPT Omission and Commission scores to create an Inattentive only group (Group One) and an Impulsive only group (Group Two), did not produce significant differences between Groups One and Two when using ANOVA to test for performance differences on the dependent measures; 3) regression analyses undertaken to further assess the relationship between Omission and Commission error scores and scores on the dependent measures found the CPT scores to be significant predictors for several of the dependent measures; 4) specific combinations of Omission and Commission error scores (resembling those obtained by Groups One, Two and Three) did not yield predicted values for the dependent variables supportive of the hypothesized relationships under investigation.

Table I: Means for ADD and Normal Children

	ADD Sample		Controls	
	mean	SD	mean	SD
CPT X-Trial Total Errors	8.12	8.15	5.19	5.45
CPT X-Trial Omission	2.64	3.58	1.25	1.40
CPT X-Trial Commission	5.49	6.34	3.94	5.00
CPT BX-Trial Total Errors	19.66	18.80	11.14	15.41
CPT BX-Trial Omission	8.23	7.35	5.17	5.93
CPT BX-Trial Commission	11.74	16.69	5.97	14.78
MFFT Total Errors	13.55	6.62	8.56	5.10
MFFT IR-Index	0.21	1.68	-0.78	1.67
SNAP Inattention	9.67	3.38	2.75	2.68
SNAP Impulsivity	10.85	3.83	2.11	2.07
PIC Acting Out	74.84	22.26	46.47	7.31
PIC Cognitive Dev.	58.52	20.51	45.33	8.72

raw scores before transformation

Table II: Analysis of Variance Comparing ADDs and Normals on CPT Error Scores

CPT-X Trials

Dep. Var.	Group SS	Error SS	DF	F	P
Total Errors	4.08	91.94	1,147	6.53	0.012*
Omission	2.66	91.94	1,147	4.69	0.032*
Commission	2.19	101.15	1,147	3.20	0.076

CPT-BX Trials

Dep. Var.	Group SS	Error SS	DF	F	P
Total Errors	11.10	99.87	1,142	15.78	0.000*
Omission	5.08	105.76	1,142	6.82	0.010*
Commission	12.29	135.39	1,142	12.89	0.000*

Table III: Means of Sub-groups Created Using CPT X-Trial Error Scores

	Group One		Group Two		Group Three	
	mean	SD	mean	SD	mean	SD
CPT Omission	5.15	3.05	0.89	0.88	2.31	4.00
CPT Commission	3.07	2.11	9.21	7.02	4.81	6.67
MFFT Total Errors	17.00	8.50	14.11	6.01	11.58	5.13
MFFT IR-Index	0.70	2.26	0.60	1.24	-0.20	1.47
SNAP Inattention	9.78	3.39	9.61	4.14	9.71	3.01
SNAP Impulsivity	10.26	4.37	10.57	3.73	11.26	3.62
PIC Acting Out	73.41	27.72	72.79	25.97	76.50	17.25
PIC Cognitive Dev.	53.74	21.96	57.39	24.42	61.29	17.47

Group One= high omission, low commission; N=27
Group Two= low omission, high commission; N=28
Group Three= others; N=58

Table IV: Means of Sub-groups Created Using CPT BX-Trial Error Scores

	Group One		Group Two		Group Three	
	mean	SD	mean	SD	mean	SD
CPT Omission	15.39	5.19	5.46	3.36	5.40	6.08
CPT Commission	5.81	5.25	22.23	13.50	6.02	8.83
MFFT Total Errors	16.92	7.30	14.50	4.66	11.16	6.08
MFFT IR-Index	0.81	1.76	0.41	1.83	-0.25	1.46
SNAP Inattention	10.69	2.65	11.04	3.41	8.54	3.39
SNAP Impulsivity	11.31	3.75	11.89	3.12	10.00	4.04
PIC Acting Out	78.92	14.18	79.73	25.61	70.58	23.65
PIC Cognitive Dev.	62.85	15.716	60.15	18.55	55.02	22.69

Group One= high omission, low commission; N=26
Group Two= low omission, high commission; N=26
Group Three= others; N=57

Table V: CPT X-Trial Regression Analyses

Dep. Var.: MFFT Impulsivity-Reflectivity
Multiple R^2: .098 Std. Error of Est.: 1.619 N=113

Variable	Coefficient	Std. Error	Std. Coeff	T	P
Constant	-1.274	0.494	0.000	-2.58	0.011
Commission	0.695	0.295	0.343	2.36	0.020*
Omission	1.224	0.430	0.580	2.85	0.005*
Interaction	-0.462	0.221	-0.523	-2.09	0.039*

Dep. Var.: MFFT Total Errors
Multiple R^2: .137 Std. Error of Est.: .942

Variable	Coefficient	Std. Error	Std. Coeff	T	P
Constant	-0.721	0.287	0.000	-2.51	0.014
Commission	0.328	0.171	0.273	1.92	0.058
Omission	0.871	0.250	0.695	3.48	0.001*
Interaction	-0.282	0.128	-0.538	-2.20	0.030*

Dep. Var.: SNAP Impulsivity Scale
Multiple R^2: .059 Std. Error of Est.: 3.760

Variable	Coefficient	Std. Error	Std. Coeff	T	P
Constant	12.275	1.148	0.000	10.69	0.000
Commission	-0.878	0.684	-0.191	-1.28	0.202
Omission	-2.195	.998	-0.458	-2.19	0.030*
Interaction	1.255	0.513	0.624	2.45	0.016*

Table VI: Predicted Values For Dependent Variables Using Different Combinations of CPT X-Trial Commission and Omission Score Values

Commission/ Omission	Predicted MFFTI-R	Commission Value	Omission Value
Min,Min	-1.27	0.0	0.0
Min,Max	2.28	0.0	2.9
Max,Min	1.16	3.5	0.0
Max,Max	0.02	3.5	2.9

Mean MFFTI-R score= 0.21 SD= 1.7

Commission/ Omission	Predicted MFFT Errors	Commission Value	Omission Value
Min,Min	-0.72	0.0	0.0
Min,Max	1.80	0.0	2.9
Max,Min	0.43	3.5	0.0
Max,Max	0.09	3.5	2.9

Mean MFFT Total Errors (standardized) = 0.16 SD= 1.0

Commission/ Omission	Predicted SNAP Imp.	Commission Value	Omission Value
Min,Min	12.28	0.0	0.0
Min,Max	5.90	0.0	2.9
Max,Min	9.20	3.5	0.0
Max,Max	15.58	3.5	2.9

Mean SNAP Impulsivity Scale Score= 10.85 SD= 3.8

Min= Minimum (Log) CPT Error Score Value
Max= Maximum (Log) CPT Error Score Value
Means and Std. Deviations are for ADD group only

Table VII: CPT BX-Trial Regression Analyses

Dep. Var.: MFFT Total Errors
Multiple R^2: 0.154 Std. Error of Estimate: 0.915 N=109

Variable	Coefficient	Std. Error	Std. Coeff.	T	P
Constant	-0.867	0.245	0.000	-3.54	0.001
Commission	0.162	0.088	0.169	1.85	0.068
Omission	0.373	0.108	0.318	3.47	0.001

Dep. Var.: PIC Cog. Dev. Scale
Multiple R^2: 0.091 Std. Error of Estimate: 19.696

Variable	Coefficient	Std. Error	Std. Coeff.	T	P
Constant	32.435	9.131	0.000	3.55	0.001
Commission	9.060	4.609	0.454	1.97	0.052
Omission	11.349	4.679	0.466	2.43	0.017
Interaction	-3.381	2.172	-0.484	-1.56	0.123

Dep. Var.: PIC Cog. Dev. Scale (without interaction)
Multiple R^2: 0.07 Std. Error of Estimate: 19.828

Variable	Coefficient	Std. Error	Std. Coeff.	T	P
Constant	44.008	5.338	0.000	8.24	0.000
Commission	2.525	1.917	0.127	1.32	0.191
Omission	5.029	2.342	2.342	2.15	0.034

Dep. Var.: SNAP Inattention Scale
Multiple R^2: 0.164 Std. Error of Estimate: 3.164

Variable	Coefficient	Std. Error	Std. Coeff.	T	P
Constant	3.224	1.467	0.000	2.20	0.030
Commission	3.085	0.740	0.924	4.18	0.000
Omission	2.906	0.752	0.712	3.87	0.000
Interaction	-1.295	0.349	-1.107	-3.71	0.000

Dep. Var.: SNAP Impulsivity Scale
Multiple R^2: 0.074 Std. Error of Estimate: 3.737

Variable	Coefficient	Std. Error	Std. Coeff.	T	P
Constant	5.905	1.733	0.000	3.41	0.001
Commission	2.381	0.875	0.635	2.72	0.008
Omission	2.282	0.888	0.498	2.57	0.012
Interaction	-1.047	0.412	-0.797	-2.54	0.012

Table VIII: Predicted Values For Dependent Variables Using Different Combinations of BX-Trial Commission and Omission Score Values

Commission/ Omission	Predicted MFFT Errors	Commission Value	Omission Value
Min,Min	-0.87	0.0	0.0
Min,Max	0.40	0.0	3.4
Max,Min	-0.87	4.0	0.0
Max,Max	1.04	4.0	3.4

Mean MFFT Total Errors (standardized)= 0.16 SD= 1.0

Commission/ Omission	Predicted PIC Cognitive	Commission Value	Omission Value
Min,Min	32.40	0.0	0.0
Min,Max	71.00	0.0	3.4
Max,Min	68.40	4.0	0.0
Max,Max	61.10	4.0	3.4

Mean PIC Cog. Dev. Factor scale= 58.2 SD= 20.5

Commission/ Omission	Predicted SNAP Inatt.	Commission Value	Omission Value
Min,Min	3.20	0.0	0.0
Min,Max	13.10	0.0	3.4
Max,Min	15.60	4.0	0.0
Max,Max	7.80	4.0	3.4

Mean SNAP Inattention Scale Score= 9.70 SD= 3.4

Commission/ Omission	Predicted SNAP Imp.	Commission Value	Omission Value
Min,Min	5.90	0.0	0.0
Min,Max	13.70	0.0	3.4
Max,Min	15.5	4.0	0.0
Max,Max	9.0	4.0	3.4

Mean SNAP Impulsivity Scale Score= 10.8 SD= 3.8

Min= Minimum (Log) CPT Error Score Value
Max= Maximum (Log) CPT Error Score Value
Means and Std. Deviations are for ADD group only

Discussion

This investigation was designed to test for specific individual differences in the symptoms of inattention and impulsivity among ADD children. A computerized version of the Continuous Performance Test (CPT) provided basic measures of inattention and impulsivity for the ADD sample in the form of Omission and Commission errors respectively. ADD children's CPT scores were compared to their scores on other measures of inattention and impulsivity, namely the Matching Familiar Figures Test (MFFT), the Personality Inventory for Children (PIC) factor scales One and Four (Acting Out and Cognitive Development respectively), and the SNAP Inattention and Impulsivity scales.

Distinguishing ADD from normal children. The first hypothesis under investigation stated that the computerized CPT utilized in this study would differentiate between normal control children and ADD children. This hypothesis was affirmed by the analyses. The two versions of the CPT administered, the X-Trial and the BX-Trial, both yielded robust differences between the normal and ADD children on Total CPT errors. This result is consistent with finding of other investigators (Michael et al., 1981; O'Dougherty et al., 1984; Sostek et al., 1980). However, for the X-Trial version, Commission errors alone did not prove significantly different between the two groups. Yet, for the BX-Trial version of the CPT, Commission errors strongly

differentiated normal and ADD children. The explanation of the difference in Commission error scores between the two versions of the CPT is most likely a function of the difference in the difficulty of the two tasks. For the X-Trial version, the task was simply to press a button when the target letter "X" appeared while for the BX-Trial version, the task was complicated by defining the target as the letter "X" only when preceded by the letter "B". ADD children made twice as many Commission errors during the BX-Trial version as the X-Trial version and normal children also made more Commission errors during the BX-Trial version than the X-Trial version. The simplicity of the designated target in the X-Trial version did not yield a significant number of mistaken responses (Commission errors). The difference in the number of errors made on the X-Trial version of the CPT as compared to the BX-Trial version is consistent with the difficulty of the differing target criteria of the two tasks. An earlier investigation did not find commission errors to differentiate normal from ADD children for either an X-Trial or a BX-Trial version of the CPT, while omission errors were found to differentiate the two groups (Sykes et al., 1971). However, another study which utilized both an X-Trial and a BX-Trial version of the CPT did find omission and commission errors to differentiate normal from ADD children (Michael et al., 1981). These two studies utilized samples of ADD children similar in age to this investigation (6-13 and 5-12 years respectively) but

the methods of administering the CPT were somewhat different. Sykes et al. (1971) used interstimulus intervals of 1 and 1.5 seconds with an unspecified stimulus duration and size. Michael et al. (1981) used an interval of 1 second and a duration of .2 seconds with a stimulus size of 5X4 cm. There is little report of the impact of differing the several variables pertinent to the CPT. Sykes et al. (1971) found a significant difference in omission errors when varying the interstimulus interval from 1 to 1.5 seconds. Stimulus duration and size may also have a significant role in CPT performance, implying that comparing investigations which have utilized different methods in administering the CPT is difficult.

Comparing sub-groups of ADD children. The major hypotheses under investigation involved the differentiation of ADD children according to their varying manifestations of inattention and impulsivity. Specifically, some ADD children were hypothesized to be inattentive but not particularly impulsive (Group One) or conversely, not particularly inattentive but impulsive (Group Two) with the remainder of ADD children exhibiting some combination of both inattention and impulsivity (Group Three).

The ADD sample was divided into the three hypothesized sub-groups on the basis of their CPT Omission and Commission error scores. Those with high Omission and low Commission errors formed Group One, those with low Omission and high Commission error scores formed Group Two, and the remainder

formed Group Three. The other independent measures of inattention and impulsivity were then used to compare these three groups using analyses of variance.

The hypotheses under investigation suggested that Group One and Group Two would have significantly different scores on all of the independent measures of inattention and impulsivity including the MFFT, the PIC factor scales and the SNAP scales. The two sub-groups were each constituted of ADD children having a distinct proportion of Omission versus Commission errors which was hypothesized to represent a similar proportion in their respective problems with inattention or impulsivity. However, using an analysis of variance, no significant differences were found between groups One and Two on any of the dependent measures. These results indicate that sub-groups were not distinguished by the measures of inattention and impulsivity as hypothesized. This implies that the distinction between inattention and impulsivity may be more difficult than the paradigm proposed in this study has addressed, or this distinction may be difficult to apply to ADD children.

Regression analyses using CPT X-Trial scores. To further clarify the relationship between CPT error scores and the measures of inattention and impulsivity, the CPT scores were used as independent variables in regression analyses to predict the dependent measures of inattention and impulsivity. Two sets of analyses were undertaken, one

for the X-Trial version CPT scores and another for the BX-Trial version CPT scores.

The X-Trial regression analyses indicated that Omission and Commission error scores accounted for a significant portion of the variance when used to predict MFFTI-R, MFFT Total Errors and the SNAP Impulsivity Scale scores. Each of these dependent measures was included as an assessment of impulsivity. The proposed hypothesis stated that Commission errors would be a better predictor of impulsivity than Omission errors. However, the regression analyses did not support this premise.

The interaction between Omission and Commission errors accounted for a significant portion of the variance for each of the X-Trial regression equations mentioned. This indicates that Omission and Commission errors have a conditional influence as predictors, depending upon their respective values. An attempt to identify some systematic relationship between Omission and Commission errors yielded no meaningful pattern with respect to understanding their relative influence in predicting the dependent measures. The most salient result of the X-Trial regression equations with regard to the hypotheses under investigation is that CPT Commission errors did not predict scores on measures of impulsivity better than Omission errors.

The fact that Omission errors are good predictors of these measures of impulsivity implies that the type of attentional vigilance measured by CPT Omission errors is

related to these measures of impulsivity. For instance, the MFFT requires that a child closely attend to nuances of target stimuli in order to reject non-target stimuli. The CPT also requires close attention to the stream of potential target stimuli in order not to miss a target (make an error of Omission). A child might make an error on the MFFT through inattention to the original stimulus picture when choosing a facsimile or through inattention to the nuances of the facsimile. This error in attention or concentration might be viewed as similar to the CPT Omission error where the child's attention or concentration is insufficient to identify the target stimulus. The results suggest that there are common attentional or vigilance skills required for the MFFT and the CPT.

MFFT Errors were included to represent impulsive responding, implying that a child chooses a facsimile picture without taking the time to reflect on the details required to identify the target. This is similar to CPT Commission errors where a child chooses a non-target stimulus by not reflecting or by responding impulsively. The regression results suggest that aspects of both inattention and impulsivity are involved in the MFFT as both CPT Omission and Commission errors are good predictors of MFFT Errors and the MFFTI-R index.

Other investigators have questioned the notion that CPT omission and commission errors can be assumed to discretely represent errors of attention and impulsivity respectively

(Klee and Garfinkel, 1983; Sostek et al., 1980). They found CPT omission and commission errors correlated with measures of both attention and impulsivity as was found in this investigation. However, another study did find omission and commission errors to discretely corroborate other measures of inattention and impulsivity respectively (O'Dougherty et al., 1984).

CPT X-Trial Commission errors did not account for a significant portion of variance when predicting the SNAP Impulsivity scale. One factor which may contribute to this weak relationship is that Commission errors were not frequently made during this version of the CPT. The requirements of the task are so basic that the mean number of X-Trial Commission errors for ADD children was only 5.5 while for the BX Trial version the mean was 11.7. The opportunity for Commission errors during the X-Trial version of the CPT is somewhat restricted.

The relatively simple demand requirements of the X-Trial version of the CPT may also help explain the non-significant relationship between CPT Omission errors and the dependent measures of inattention. The mean number of Omission errors on the X-Trial version by ADD children was 2.6 while the BX-Trial version mean was 8.2. The X-Trial version of the CPT did not provoke many Omission or Commission errors which suggests that this version of the CPT is a relatively weak measure of both inattention and impulsivity, at least for elementary school are children.

Regression analyses using BX-Trial scores. The second set of regression analyses used the BX-Trial version for the CPT error scores as predictors and found they were significant when estimating the PIC Cognitive Development Scale and the SNAP Inattention scale which were included as measures of attention problems. BX-Trial error scores were also significant when estimating the MFFT Total Errors and the SNAP Impulsivity scale which were included as measures of impulsivity.

The proposed hypotheses suggested that Omission errors would predict scores on measures of inattention better than Commission errors. This hypothesis was essentially confirmed for the PIC Cognitive Development Scale but not for the SNAP Inattention Scale. The fact that the CPT Omission error scores could discriminate for inattention on one measure but not the other suggests that the two measures are assessing a different aspect of attention.

The PIC Cognitive Development scale is a measure of academic achievement, particularly language skills, reading comprehension, spelling and mathematics. High scores on this scale are also associated with poor social skills, lower IQ scores and sometimes poor motor coordination (Lachar,1975). The regression results indicate that some aspect of behavior is common to missing target stimuli on the CPT (Omission errors) and scoring poorly on this measure of cognitive development. This investigation has suggested

that the common characteristic is attention, or more specifically sustained vigilance to a task. The results infer that a child's ability to sustain attention is important to achieve academically, and possibly to attain good social skills. Other possible contributing factors to the relationship between Omission errors and the PIC Cognitive Development scale could be a child's perceptual ability and motor coordination which would be clearly relevant to the CPT task. A child must maintain sufficient perception of the CPT stimuli to make accurate judgments and then the child must translate the perception into a button press response. Problems with either perception or motor coordination would likely increase Omission errors on the CPT. Other investigators have described ADD children as having problems with both perceptual sensitivity (O'Dougherty et al., 1984) and motor coordination (Barkley, 1981). The PIC Cognitive Development factor scale measures a complexity of characteristics, some of which appear to be pertinent to performance on the CPT. Specifically, attention and possibly perceptual and motor skills are implied to be involved in performance on both measures.

The SNAP Inattention scale is by comparison a much simpler scale (5 items) focusing on a child's ability to sustain attention during tasks. The regression results indicate that missing target stimuli (Omission errors) and responding to non-target stimuli (Commission errors) are both related to a child's ability to sustain attention in

daily tasks (SNAP Inattention Scale). The fact that both Omission and Commission errors are related to scores on the SNAP Inattention scale implies that both inattentive and impulsive responding are related to a child's ability to attend to tasks.

The BX-Trial set of regression equations also found CPT errors to be significant predictors for two measures of impulsivity, MFFT Total Errors and the SNAP Impulsivity scale. The proposed hypotheses suggested that Commission errors would predict these two measures better than Omission errors. However, Omission errors proved a significant predictor for MFFT Total Errors while Commission errors did not. One interpretation of this finding is that MFFT errors (choosing non-target stimuli) might be committed through inattention to the target criterion (Omission) rather than impulsive responding (Commission). The BX-Trial results indicate that the behavior measured by CPT Commission errors and the MFFT are not particularly related. This conclusion implies that either the MFFT does not measure impulsivity, CPT Commission errors do not measure impulsivity or they each measure different aspects of impulsivity. Other investigators have also suggested that CPT commission errors are not discretely correlated with impulsivity (Klee and Garfinkel, 1983; Sostek et al., 1980).

For the SNAP Impulsivity scale, Omission errors, Commission errors and their interaction were significant predictors. Again, the interaction indicates that Omission

and Commission errors have a conditional influence depending on their relative values. No relevant pattern could be determined for the influence of this interaction on the predicted SNAP Impulsivity scale score. These results could be interpreted to suggest that acting without stopping to reflect, which is the focus of the SNAP Impulsivity Scale, is a function of both inattention to task criterion and impulsive responding. This interpretation is consistent with the DSM-III diagnosis of ADD children which describes symptoms of both inattention and impulsivity (American Psychiatric Association, 1980).

Limitations and future directions. The most prominent limitation brought out in this study was the difficulty in specifying what the Continuous Performance Task, the MFFT, the PIC and the SNAP were actually measuring. While these measures have been used to identify ADD children in numerous studies as having deficits with attention and impulsivity, a specific definition of the nature of the attention or impulsivity deficits measured has not been well established. Trying to distinguish ADD children on the basis of these measures proved difficult in part because inattention and impulsivity turned out to be inter-related constructs. Future research might attempt to more specifically delineate the nature of the inattention and impulsivity assessed by these measures, perhaps focusing on the underlying components of these constructs.

This study did not make provision for measuring the

decrement in sustained attention over time during the CPT task. Other investigators have found a vigilance decrement over time when testing ADD children (Kupietz and Richardson, 1978). If such a decrement was evidenced more by one type of CPT error score than another this might provide further information for distinguishing between attention and impulsivity deficits.

The CPT used in this investigation employed a fixed interval between stimuli presented to the subject (1.2 seconds). Using a shorter or longer stimulus interval would change the demand characteristics of the task and perhaps change the type of difficulty and consequent errors made during the CPT. Future research might try various interstimulus interval lengths to determine which might be most sensitive to the type of errors ADD children are most prone to make. Sostek et al. (1980) increased the interstimulus interval by 5% when a subject made a correct response and decreased the interval by 5% when an error was made thus providing some adaptation to individual error rates although forgoing an easy means of comparing different individuals.

The use of the CPT is somewhat inhibited by a lack of accepted standards for administration. Different investigators utilize different stimuli (letters, numbers, figures), different size stimuli, different rates of presentation, different means of administration and different formulas for analyzing errors. Future research

might be devoted to establishing some optimum standards for administration. A dedicated, low cost CPT software program compatible with the more prevalent micro-computers would provide much toward solving the current lack of standardization in administering the CPT.

Synopsis. In summary, some ADD children were hypothesized to have differing manifestations of problems with inattention and impulsivity rather than the homogeneous experience of these symptoms that the DSM-III diagnosis of ADD describes. To test this hypothesis a computerized version of the CPT was proposed as a measure of inattention (Omission errors) and impulsivity (Commission errors) and was found to differentiate ADD from normal children. CPT errors were used to separate ADD children into sub-groups depending upon the number of Omission versus Commission errors made. Sub-groups created on the basis of CPT scores were hypothesized to represent ADD children with: 1) problems with inattention but not problems with impulsivity; 2) problems with impulsivity but not inattention; and 3) problems with inattention and impulsivity. These three groups were compared on other measures of inattention and impulsivity including the MFFT, PIC factor scales One and Four, and the SNAP Inattention and Impulsivity scales. The sub-groups One and Two failed to show significant differences on any of these measures of inattention and impulsivity.

Regression analyses were used to test the hypotheses that Omission errors would predict scores on the measures of inattention better than Commission errors and that Commission errors would predict scores on measures of impulsivity better than Omission errors. These hypotheses were not supported by the results. The X-Trial version of the CPT may be too simple a task to be a good measure of inattention and impulsivity in elementary school age ADD children, relatively few Omission and Commission errors were generated. BX-Trial Omission and Commission errors were more frequent but did not predict scores on measures of inattention and impulsivity as hypothesized except for one measure. Omission errors were a better predictor for the PIC Cognitive Development factor scale relative to Commission errors. CPT Omission and Commission errors did not prove selective indicators of inattention and impulsivity as proposed. Part of the problem proved to be separating out the components of inattention and impulsivity from tasks that may be influenced by both problems. For instance, the MFFT was proposed as a measure of impulsivity, for which it has been traditionally used, yet the task seems heavily dependent on attention and concentration as the positive relationship with CPT Omission errors indicated. Distinguishing a measure's requirement for attention versus impulse control has proven more difficult than the design of this investigation has addressed. While measures were ostensibly included to assess inattention and impulsivity,

there proved little agreement between CPT errors and these measures of inattention or impulsivity. Specifically, while CPT Omission errors and the PIC Cognitive Development factor scale did evidence some common relationship, SNAP Inattention scale scores did not. CPT Commission errors did not prove specifically sensitive to the MFFT, the PIC Acting Out factor scale or the SNAP Impulsivity scale. Identifying CPT Omission errors as an index specific to inattention and CPT Commission errors as an index specific to impulsivity was not well supported by this investigation.

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