Assessment of Children's Attention: Predicting Attention-Deficit/Hyperactivity Disorder Diagnoses

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Abstract
The aim of this study was to investigate the value of a measure of children's attention to predict ADHD diagnoses. Theoretical and empirical literature on ADHD, children's attention, assessment of children's attention, and the TEA-Ch (Thames Valley Test Company, 1999), an objective measure of the attention, were reviewed. The TEA-Ch was designed without cutoff or overall scores from which to make inferences on performance. In an attempt to demonstrate the clinical utility of the measure, this study empirically investigated the strength of children's performance on the TEA-Ch to accurately predict the presence or absence of an ADHD diagnosis, as well as relations between age, gender, and diagnosis. Additionally, cut points were established to investigate another method for identifying diagnoses with the TEA-Ch. Participants included 166 clinic-referred children whom received psychoeducational evaluations. Three subtests of the TEA-Ch were used as predictors of diagnosis. Results indicated that none of the subtests served as significant predictors of the presence or absence of an ADHD diagnosis. Contrary to expectation, the sustained attention component of the TEA-Ch did not serve as a better predictor than the selective and switching attention components. Similarly, the cut point findings were also contrary to expectation in that typical performance as opposed to low performance served as a better identifier of diagnosis for all three attention components. Consistent with expectations, the 2 standard deviation cut points yielded higher percentages of correctly identified cases. There were no significant differences in performance on the TEA-Ch between the children with and without ADHD diagnoses. As expected, there were significant relations between both age and gender and diagnosis the sample. Future research should include all subtests of the TEA-Ch as predictors of ADHD.

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ASSESSMENT OF CHILDREN’S ATTENTION:
PREDICTING ATTENTION-DEFICIT/HYPERACTIVITY DISORDER DIAGNOSES

A THESIS
SUBMITTED TO THE FACULTY
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APPROVED: ________________
Susan Tinsley Li, PhD
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The aim of this study was to investigate the value of a measure of children’s attention to predict ADHD diagnoses. Theoretical and empirical literature on ADHD, children’s attention, assessment of children’s attention, and the TEA-Ch (Thames Valley Test Company, 1999), an objective measure of the attention, were reviewed. The TEA-Ch was designed without cutoff or overall scores from which to make inferences on performance. In an attempt to demonstrate the clinical utility of the measure, this study empirically investigated the strength of children’s performance on the TEA-Ch to accurately predict the presence or absence of an ADHD diagnosis, as well as relations between age, gender, and diagnosis. Additionally, cut points were established to investigate another method for identifying diagnoses with the TEA-Ch.

Participants included 166 clinic-referred children whom received psychoeducational evaluations. Three subtests of the TEA-Ch were used as predictors of diagnosis. Results indicated that none of the subtests served as significant predictors of the presence or absence of an ADHD diagnosis. Contrary to expectation, the sustained attention component of the TEA-Ch did not serve as a better predictor than the selective and switching attention components. Similarly, the cut point findings were also contrary to expectation in that typical performance as opposed to low performance served as a better identifier of diagnosis for all three attention components.

Consistent with expectations, the 2 standard deviation cut points yielded higher percentages of correctly identified cases. There were no significant differences in performance on the TEA-Ch between the children with and without ADHD diagnoses. As expected, there were significant relations between both age and gender and diagnosis the sample. Future research should include all subtests of the TEA-Ch as predictors of ADHD.

Keywords: Children, ADHD, TEA-Ch, attention, assessment, prediction
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Introduction

Complete and accurate assessment of ADHD that meets practice guidelines and effectively distinguishes amongst children with and without symptoms is a clinical challenge. Several different measures of children’s attention are used by a variety of mental health providers and physicians as an aid in making a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) for children. A criterion of an ADHD diagnosis, according to the Diagnostic and Statistical Manual (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000), requires that evidence of attention problems be present in at least two settings, commonly in school and at home. This criterion is frequently fulfilled by the use of subjective rating scales usually completed by parents and teachers, and sometimes even by children themselves, in which they provide their subjective opinions about target symptoms and behaviors (Pelham, Fabiano, & Massetti, 2005). Other than subjective reports of attention with various scales, inventories, and checklists, clinicians also use structured clinical interviews, observations, and continuous performance tasks for assessment of attention. One major advantage of using continuous performance tasks is that they provide objective evidence of sustained attention, but the utility of these tests are called into question because they may not engage children with attention difficulties enough to accurately demonstrate lowered performance (Chan, Wang, Ye, Leung, & Mok, 2008). In 1999, Manly, Robertson, Anderson, and Nimmo-Smith introduced the Test of Everyday Attention for Children (TEA-Ch), one of the only objective assessment measures of attention currently available. At present, there is limited empirical literature on the TEA-Ch, and a paucity of literature on the ability to predict a diagnosis of ADHD specifically with the TEA-Ch. The current study attempts to demonstrate the strength and the utility of objective measures of attention for children. Further, this study attempts to demonstrate the predictive value of the
TEA-Ch in the assessment of children’s ADHD diagnosis.

Background Information on ADHD

ADHD may be one of the most common childhood mental health conditions in the world (Faraone, Sergeant, Gillberg, & Biederman, 2003). Given the sizable prevalence of ADHD in children currently, extensive study of the disorder is warranted. According to the *DSM-IV-TR* (2000), ADHD is a chronic childhood disorder consisting of inattentive, impulsive, and hyperactive behaviors.

Features of ADHD

**Subtypes.** To account for different symptom presentations, three subtypes of ADHD are classified in the *DSM-IV-TR* (2000), based on the symptoms exhibited in the past 6 months: Combined Type (ADHD-C), Predominantly Inattentive Type (ADHD-PI), and Predominantly Hyperactive-Impulsive Type (ADHD-PHI). ADHD-C is used to describe individuals who meet both the inattentive and hyperactive-impulsive criteria. ADHD-PI describes individuals who meet the inattentive criteria, but not the hyperactive-impulsive criteria. Conversely, ADHD-PHI is used to describe individuals who meet the hyperactive-impulsive criteria, but not the inattentive criteria. According to the *DSM-IV-TR* (2000), individuals with ADHD-PI are more likely to be diagnosed after the age of 7, which is the age of onset criteria for all subtypes. Additionally, individuals with an ADHD diagnosis may switch subtypes over the course of development, and thus, subtypes are not necessarily fixed. It should be noted, however, that evidence of subtype distribution varies widely. Differences in subtype distribution may be attributable to the method and informant used in collecting diagnostic information (Rowland et al., 2008).
**Diagnostic criteria.** Symptoms of ADHD are categorized in two domains in the *DSM-IV-TR* (2000): inattentive and hyperactive-impulsive. In the *DSM-IV-TR*, the two domains of symptoms are distinct in that the hyperactive-impulsive symptoms are descriptors of intensified quality and high level of activity, whereas the inattentive symptoms describe a behavioral style that indicates how individuals approach tasks. Children must demonstrate six or more inattentive symptoms and/or six or more hyperactive or impulsive symptoms for 6 months or longer, with some symptoms present before age 7. Inattentive symptoms include: (a) difficulty with attention to details or making careless mistakes in work, (b) difficulty sustaining attention in activities of play or work, (c) appearing to not listen when being spoken to, (d) difficulty following through with tasks, (e) difficulty with organizing, (f) avoiding or disliking activities of sustained mental effort, (g) losing possessions needed for participation in activities, (h) distractibility with objects or activity in the environment, and (i) forgetfulness in daily activity. Hyperactive-impulsive symptoms include: (a) bodily fidgetiness or movement while seated, (b) difficulty staying seated in school or other contexts where sitting is expected, (c) excessive and inappropriate running or climbing, (d) difficulty participating in activities quietly, (e) appearing to be constantly in motion physically, (f) excessively talking, (g) blurting out answers before questions are asked, difficulty taking turns, and (h) interrupting or disrupting others in conversation or activity. The symptoms are required to be more severe than would be developmentally expected. Symptoms of ADHD must significantly impair social, academic, or occupational functioning and be present in at least two settings, often at school and in the home. Lastly, ADHD symptoms must not occur only in the presence of another mental disorder or be better accounted for by another mental disorder, such as a Pervasive Developmental Disorder.
Prevalence. The *DSM-IV-TR* (2000) estimates the prevalence rate for childhood ADHD at 3-5%; however, rates reported in the literature have varied widely. Reported rates may differ due to differences in study inclusion criteria, such as clinic-referred versus community samples and cultural or geographic location variation in epidemiological studies (Barkley, 2003). Variability in prevalence rates in both in the U.S. and worldwide may additionally be attributable to differences in the methodology of epidemiological studies (*DSM-IV-TR*, 2000; Polanczyk & Rohde, 2007; Skounti, Philalithis, & Galanakis, 2007). Polanczyk and Rohde (2007) noted differences in sources of diagnostic criteria, informants, symptom combinations across versus between informants, and definitions of impairment have likely accounted for fluctuations in prevalence rates. Skounti, Philalithis, and Galanakis (2007) cited similar methodological differences as the potential source for variation in prevalence, including the requirement that symptoms be present in one or two settings, diagnostic criteria, and definition of impairment. Based on reviews of epidemiological literature and accounting for methodological differences, Polanczyk and Rohde (2007) estimated that the worldwide prevalence of ADHD was approximately 5.29% in the non-adult population, whereas Skounti et al. (2007) estimated that worldwide prevalence of ADHD was between 2.2 to 8.9% in children and adolescents when a two setting requirement is used.

Although cultural differences likely have some impact on the understanding, diagnosis, treatment, and course of the disorder, ADHD has been consistently demonstrated as a worldwide phenomenon (Polanczyk & Rohde, 2007; Polanczyk, Silva de Lima, Horta, Biederman, & Rohde, 2007). Likewise, Bauermeister, Canino, Polanczyk, and Rohde (2010) demonstrated through factor analyses of studies conducted with children in 15 countries across the world that ADHD is seen cross-culturally and is not simply a Western disorder. The widespread
acknowledgement of ADHD throughout the world underscores the need for research and clinical understanding on this topic.

**Developmental course.** ADHD has been conceptualized largely as a disorder of childhood with symptoms often remitting in adolescence and a smaller proportion of cases experiencing symptoms that persist into adulthood (*DSM-IV-TR*, 2000). However, awareness of the sequelae of ADHD in adulthood has slowly developed in recent years, and the perception of the disorder being one of childhood alone is changing (Barkley, Smallish, Fletcher, & Smallish, 2006). In a follow-up study of individuals diagnosed with hyperactivity in childhood, Barkley, Fischer, Smallish, and Fletcher (2006) reported that between 46% and 66% would qualify for a diagnosis of ADHD as young adults according to parental report.

Alternatively, the developmental course of ADHD may have less to do with symptom remittance over time as with changes in symptom presentation associated with development, as seen in subtype shifting from early childhood to young adulthood. Rowland et al. (2008) cited arguments that the criteria for ADHD in the *DSM-IV-TR* may not be reflective of developmental differences. Subtypes may actually differentiate symptom presentations observed at various age levels rather than true group differences within the disorder. Similarly, ADHD subtypes have been demonstrated to be relatively unstable over time, with ADHD-PHI being most common in the preschool population, ADHD-C being most common throughout childhood, and ADHD-PI most common in adolescents and adults with residual symptoms in adulthood (Todd et al., 2008). Although it is clear that ADHD causes impairment in childhood and young adolescence, there is growing evidence to suggest that the course of ADHD may be longer than once was originally purported.
**Gender.** ADHD has traditionally been considered a disorder affecting young males, with clinic-referred children much more likely to be boys than girls (*DSM-IV-TR*, 2000). Barkley (2003) suggested that the externalizing behavior problems of ADHD associated with the high comorbidity of disorders such as Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD) in boys with ADHD likely account for the higher frequency of clinic referrals than seen for young girls. Outcomes of recent research on gender differences have suggested that there is still evidence that more male children are diagnosed with ADHD than female children. Sex ratios obtained from studies of clinic-referred populations have been criticized for inaccurately depicting true characteristics of the ADHD population because of the male-referral bias that occurs (Bauermeister et al., 2007). Recent studies utilizing only community samples of young people reported the following male-to-female ratios in various geographic locations: 5:1 overall in 10 western European countries (Novik, Hervas, Ralston, Pereira, & Lorenzo, 2006), 2.3:1 in Puerto Rico (Bauermeister et al., 2007), and 2.8:1 in the state of Mississippi (Ramtekkar, Reiersen, Todorov, & Todd, 2010). These figures are relatively consistent with the *DSM-IV-TR* (2000) reported range of sex ratio of 2:1 to 9:1, which differ based on clinic-referred versus community-based samples.

Evidence is mixed as to whether or not other aspects of ADHD symptomatology and comorbidity vary by gender. Bauermeister et al. (2007) suggested that the sequelae of childhood ADHD is similar for boys and girls, although girls with ADHD-PI tend to have comorbid anxiety disorders more than boys and boys with ADHD-C may be at greater risk for developing depressive symptoms than girls. Similarly, Novik, Hervas, Ralston, Pereira, and Lorenzo (2006) reported that ADHD in boys and girls is more similar than different, even in symptom severity, duration, and comorbid disorders. Ramtekkar, Reiersen, Todorov, and Todd (2010), however,
found in their Mississippi study that young males had more severe ADHD symptoms than young girls. Furthermore, ADHD-PI was the most common subtype in both males and females, which they suggested may mean that this subtype is both under-represented in treatment and that ADHD may often go undiagnosed in young females (Ramtekkar et al., 2010). As with differences in prevalence rates, gender differences can vary depending on the setting. Barkley (2003) noted that young girls are far less likely to have co-occurring externalizing behavior problems that would lead to a clinic referral for behavior problems than young boys, and this referral bias may have some impact on reported sex ratios.

**Diagnostic issues.** One of the challenges in diagnosing ADHD is that the criteria encompass behavior that can be representative of normal development in one age group and immature or delayed in another. The *DSM-IV-TR* (2000) criteria stipulate that symptom behavior be inappropriate for an individual’s developmental level and that functional impairment must be present, but the exact definitions of these are unclear (Polanczyk & Rohde, 2007). Further criticism has focused on the fact that the criteria are reflective of behaviors seen in elementary school-age children, but are not particularly useful when applied to preschool-age children (Posner et al., 2007), nor with adolescents or adults, in which the criteria may ignore abnormal adult behavior (Barkley, 2010). Posner et al. (2007) noted that many preschool children will likely meet criteria for most of the hyperactive criteria because those behaviors are relatively ubiquitous among children in this age range.

Another difficulty in diagnosing ADHD is the high comorbidity rates associated with this disorder. It is documented in the *DSM-IV-TR* (2000) that approximately half of all clinic-referred children diagnosed with ADHD are likely to have externalizing behavior problems with a comorbid ODD or CD diagnosis. The *DSM-IV-TR* (2000) acknowledges another pattern of
comorbid disorders often associated with ADHD, which include anxiety disorders, mood disorders, learning disorders, and communication disorders. In a study of clinic-referred youth, Elia, Ambrosini, and Berrettini (2008) reported a much higher figure than in the *DSM-IV-TR* (2000) such that nearly 2/3rds of their had concurrent comorbid diagnoses, most frequently ODD, minor depression/dysthymia, and generalized anxiety disorder (GAD). Comorbidity with ADHD might be associated more with specific features related to ADHD, such as gender, than with the disorder in general. Furthermore, disorders comorbid with childhood ADHD may be more stable into adolescence for young women than for young men (Monteaux, Mick, Faraone, & Biederman, 2010).

Although different from the behavioral issues associated with ADHD, academic problems are among the most frequently cited difficulties co-occurring with ADHD (Preston, Heaton, McCann, Watson, & Selke, 2009). Preston, Heaton, McCann, Watson, and Selke (2009) found academic impairment in children with ADHD may not always be accounted for by a specific learning disorder, suggesting perhaps that some of the academic difficulty experienced by these children may actually be cognitive deficits associated with the disorder. This idea is consistent with a finding from Hood, Baird, Rankin, and Isaacs (2005) that there may be cognitive attention difficulties specific to ADHD. Some children with ADHD may have both learning disorders and cognitive attention impairments. Overall, the prevalence and variability of other disorders presenting in children with ADHD may complicate proper identification of ADHD in clinical settings.

**Summary**

ADHD is a well-studied disorder of childhood, adolescence, and even adulthood. The prevalence of ADHD is probably between 3% and 9%, but rates vary greatly depending on the
setting, methodology, and sample of individuals included. It appears clear that, contrary to the idea that it is an American or Western disorder, ADHD has been documented as a prominent disorder throughout the world. Subtypes of ADHD represent differences in presenting problems, with individuals with ADHD-PHI and ADHD-C likely to display more behavioral problems and individuals with ADHD-PI more likely to display an inattentive approach to tasks. Individuals diagnosed with ADHD may switch subtypes over the course of development, and this is not unusual. It may be that ADHD-C better represents the disorder overall, and that ADHD-PI may be related to a distinct disorder. The presentation of ADHD-PHI and ADHD-C do appear to be different from the presentation for ADHD-PI.

Although it was once believed that ADHD was only a diagnosis for young unruly boys, years of research have demonstrated that ADHD may exist in males and females, with sex ratios approximately between 2:1 and 9:1. Evidence for comorbidity with the disorder is mixed, but it still appears relevant that boys are more likely than girls to have comorbid externalizing behavior problems. Children with ADHD are overwhelmingly likely to have a comorbid disorder of some kind, most commonly behavior disorders and learning disorders. In addition to comorbidity, issues related to development can make diagnosing ADHD difficult. Because the diagnostic criteria require that presenting symptoms of ADHD be unreasonable according to an individual’s developmental level, and because the criteria may be limiting in that they are framed largely in terms of behaviors seen in elementary school children, the youngest children, adolescents, and adults may be hard to diagnose. Along with diagnostic issues that make diagnosing ADHD a complex process, it should be noted that assessment of ADHD can also be challenging. Specific issues related to assessment of ADHD will be addressed later. Before delineating some of the
salient points of objective assessment in children’s attention, a discussion of theories related to attention and ADHD follows.

**Theory and Models of ADHD and Attention**

Attention problems seen in clinical settings have received much attention in psychology. Traditional clinical identification, assessment, and treatment of ADHD in children have been covered thoroughly in the literature. It is important to note, however, that ADHD as a clinical issue may differ from the theoretical understanding of ADHD (Barkley, 2007a). It is also the case that the current conceptualization of ADHD may not directly map onto the construct of attention. Models of attention discussed here are generally focused on the number and type of factors that comprise attention for the population of interest, while models of ADHD tend to be more focused on the contribution of certain cognitive/neuropsychological elements that are likely to account for impairment from the disorder. Attention is comprised of multiple components and is not a unitary construct (Posner & Peterson, 1990). Similarly, a one-process theory of ADHD likely does not account for the variability of presentation within and across subtype groups of children with ADHD (Nigg, 2005b). Although theories and models of ADHD and attention may appear distinct from the clinical version of ADHD, incorporating these theories into the conceptualization of ADHD may better inform the current understanding, and therefore, current assessment practices, of the disorder.

**Barkley’s Theory of ADHD**

Although several theories of attention in ADHD have been proposed, Nigg (2005b) remarked that recent theories of ADHD seem to have decreased focus on the actual concept of attention. One such demonstration of this point occurs in a prominent theory on ADHD proposed by Barkley (1997a,b), which is not a theory of attention, per se. Out of criticism for the current...
clinical conceptualization of ADHD in children, Barkley (1997a) proposed a theory and model of
deficits in behavioral inhibition as the hallmark of ADHD. Barkley noted that the present
conceptualization according to DSM-IV criteria is not theory-driven, but rather behavior-driven,
as evidenced in part by the absence of criteria referencing difficulty in motor development and
deficits in executive functioning commonly observed in children with ADHD. Barkley (1997a)
suggested that children with hyperactivity and impulsivity (e.g., ADHD-C and ADHD-PHI) are
disparate from children with inattention only, but the behavioral inhibition model does not
specifically address ADHD-PI.

Barkley’s model is one of difficulty developing behavioral inhibition, which is partially
responsible for the performance of four executive functions: working memory, regulation of
affect/motivation, internalization of speech, and reconstitution. Barkley suggested that
nonverbal working memory is important for monitoring ongoing behavior, regulation of
affect/motivation is related to the role emotion plays in behavior, internalization is key in
applying rules and appraisal of behavior, and reconstitution is involved in the adjustment of
behavior for positive social interactions. Barkley further proposed that these four factors of
behavioral inhibition, when applied to ADHD, would be impaired. These impairments likely
lead to some of the dysfunctional behaviors observed in children with ADHD. In contrast to
Barkley’s behavioral inhibition theory of ADHD, other researchers have focused their efforts on
developing models on the construct of attention.

Mirsky and Colleagues’ Model of Attention and ADHD

Based on years of research on brain injury, Mirsky, Pascualvaca, Duncan, and French
(1999) developed a model of attention by factor analyzing data from a series of
neuropsychological tasks administered to a large group children and adults. Mirsky et al. (1999)
identified four functions of attention from this analysis including focus/execute, sustain and stabilize, shift, and encode. The focus/execute function is described as devoting attentional resources to specific tasks and filtering out extraneous stimuli. The sustain function is explained as vigilance to a task over a significant amount of time, in which target stimuli are not missed, and the stabilize function is described as the variability in response time on a sustained attention task. The shift function is explained as the flexibility to move back and forth from one task to another. Finally, the encode function is related to the concept of working memory and is described as holding information briefly and manipulating it in some way. From this, Mirsky et al. (1999) asserted that attention is a process of multiple functions, and cannot be explained by one function alone. Further, they asserted that these functions arise from different, specialized brain regions that make up the attention system in the brain. Damage to any of these regions may lead to impairment, but it is possible that the attention system can accommodate some injuries and can supply alternative ways to support various attention functions (Mirsky et al., 1999).

Mirsky et al. (1999) applied their four function model of attention to a group of clinic-referred children diagnosed with ADHD and a group of community control children and found that the ADHD group demonstrated impairment in the focus/execute, shift, and sustain and stabilize functions of attention. These attention impairments were explained as a developmental lag particular to children with ADHD, in which these children may eventually be on par with their non-ADHD peers, but that these deficits may put ADHD children at risk for academic difficulty (Mirsky et al., 1999). Additionally, the authors of this model were surprised to find that children with ADHD and no comorbid diagnoses were more impaired on the sustain attention function than children with ADHD and comorbid learning disorders, and that some
cognitive impairment associated with ADHD is distinct from that of learning disorders. It is observable from Mirsky et al.’s model of attention that the focus is on the components of attention. This differs from the neuropsychological bases of impairment proposed in Barkley’s model. It is clear that models of attention and models of ADHD have different conceptualizations; however, both types of models appear to be relevant for understanding, in part, childhood ADHD.

**Posner’s Contribution to the Theory of Attention**

Posner and Peterson (1990) outlined mounting evidence in the field of human attention and brain research highlighting that attention was perhaps not one single, nebulous function, but a system of various brain regions associated with specific attention functions. The seminal work of Posner and Peterson (1990) on attention claimed that human attention functions exist in a system, that separate regions of the brain were responsible for attention functions, and that attention functions are separate from each other. Further, Posner and Peterson (1990) proposed three related attention functions including orienting to sensory information, detecting target stimuli, and maintaining vigilance or alertness to task (referred to as the orienting network, the alerting network, and the executive network, respectively).

Posner and Peterson’s (1990) theory of attention continued to broaden understanding in the developing field of attention. Later, Posner contributed to research on the theory of attention in children in a project by Rueda et al. (2004) in which an objective measure of adult attention the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) was extended downward to be used with children. Children’s performance on the ANT adapted for youth was compared to adult performance on the original ANT, both of which assess for networks of attention similar to the attention functions, the orienting network, the alerting
network, and the executive network proposed by Posner and Peterson (1990). Results indicated that based on the children’s performance, the three attention networks, were demonstrated to be separate functions (Rueda et al., 2004).

**Manly and Colleagues’ Model of Attention**

More recently, Manly et al. (2001) offered a three factor model of children’s attention that includes three components: selective attention, sustained attention, and attentional control or switching. These components appear to be independent dimensions of attention rather than an overall factor of attention. This three-factor model of children’s attention flowed from an earlier model of adult attention demonstrated by the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) for adults. The standardization of the TEA gave its authors an opportunity to assess three facets of attention (spatial, selective, and sustained). Consistent with Posner and Peterson (1990), Manly et al. found that selective and sustained attention were two separate domains. In the interest of knowing whether a model of adult attention could be applied to children’s attention, Manly et al. (2001) developed the TEA-Ch. The validity of Manly et al.’s three-factor model of attention was initially established through structural equation modeling on data of the TEA-Ch standardization sample discussed later.

Manly et al. (2001) explained the nature of the three attention factors demonstrated by the TEA-Ch as follows. Selective attention was described as focus and concentration on a discrete task while filtering out extraneous information. Sustained attention is the ability to keep focus and concentration on a low-engaging task over an extended period of time, and attentional control/switching as the ability to shift focus and concentration between sets of information or to shift or inhibit performance required for a task. Discussion of these three factors herein continues with the exploration of the predictive utility of the TEA-Ch.
Summary of Theory and Models of ADHD and Attention

In comparison of children’s attention models, Mirsky et al. (1999) proposed four factors of attention, while Rueda et al. (2004) and Manly et al. (2001) proposed a three-factor model of attention. Although the exact definitions of the various factors of attention across these three models are not equal, there appears to be a good deal of overlap in attention functions that point to some kind of selective focus attention, sustained attention, and attention to various types of stimuli. These models of children’s attention are contrasted with those of adult attention, such as that of Moosbrugger, Goldhammer, and Schweizer (2006), in which two-factor model of perceptual attention (related to visual-spatial ability) and executive attention (related largely to short term memory) have been proposed based on performance on neuropsychological assessments. It appears there is greater similarity than difference between the models of children’s attention. It is also apparent that models of attention that focus on a specific factor impairment in ADHD are quite different from theories about ADHD, as in Barkley’s ADHD model of behavioral inhibition (1997a,b). Barkley’s model of ADHD is a complex theory of several neuropsychological concepts interacting in a disadvantageous way that provides some solid theoretical understanding of ADHD beyond the criteria in the DSM-IV-TR. The models of ADHD and the models of attention both have a place in understanding childhood ADHD, although integration of the two has yet to have been established.

Assessment of Attention and ADHD

Arriving at an accurate diagnosis is often the central goal of assessment, and in clinical settings, there is additional emphasis on the need for assessment to aid in case conceptualization, treatment planning, and progress monitoring (Pelham, Fabiano, & Massetti, 2005). However, there is variability around the most effective and efficient ways to assess for ADHD. In a review
of evidence-based assessment practices, Pelham, Fabiano, and Massetti (2005) generally recommend assessment for ADHD include traditional behavior and symptom rating scales for clinical evaluation because they are relatively efficient and cost effective for the clinician and client. However, these measures are subjective in nature because they rely on the opinion of a parent or teacher. Pelham et al. (2005) further suggested that lengthy structured clinical interviews, global assessments of impairment, and most observational assessments are superfluous to accurate diagnosis. In contrast to Pelham et al.’s position, Morein-Zamir, Hommersen, Johnston, and Kingstone (2008) question whether or not rating scales alone are enough to make informed diagnosis. Morein-Zamir et al.’s (2008) position stems from their research which supports evidence of impairment of response inhibition in children with ADHD. Similarly, Manly et al. (2001) expressed that rating scales may be the most useful diagnostic tool in demonstrating attention impairment, but that their utility is limited in that such measures do not demonstrate particular impairments. Because several factors associated with ADHD make diagnosing the disorder difficult (e.g., comorbid conditions, being older), and the sequelae of ADHD can have lasting implications (Barkley et al., 2006), measures other than rating scales are sometimes necessary. In further support of the need for additional types of attention measures, Hood et al. (2005) implied that cognitive assessment that includes objective measures of attention may be needed to detect more subtle forms of impairment in children with ADHD.

**Assessment of Sustained Attention**

In the presence of a growing demand for objective assessment measures, and because attention is a multicomponential concept, there is interest in measures that tap multiple components of attention. Heaton et al. (2001) highlighted that being able to assess multiple components of attention to demonstrate both strengths and weaknesses is advantageous. In being
able to assess multiple types of attention, significant impairment in one or more areas can be elucidated. There has been frequent agreement between researchers that sustained attention is impaired in children diagnosed with ADHD (Chan, Wang, Ye, Leung, & Mok, 2008; Hood et al., 2005; Heaton et al., 2001; Manly et al., 2001, Sutcliffe, Bishop, & Houghton, 2006). As it has been demonstrated that there are developmental trends in sustained attention in non-impaired children, there is interest in the ability to assess for deficits of sustained attention (Betts, Mckay, Maruff, & Anderson, 2006). Betts, Mckay, Maruff, and Anderson (2006) noted that although a few sustained attention measures exist, usually in the form of some kind of objective continuous performance task requiring signal detection, more research on assessment of sustained attention in children is needed. Chan, Wang, Ye, Leung, and Mok (2008) criticized the use of traditional continuous performance tasks, which provide information on only the sustained attention component, because children may not be able to employ the same engagement in these tasks as adults. Manly (2005) noted that continuous performance tasks are a unique contribution to assessment, but highlighted the potential advantage that could be gained by demonstrating shared variance on more than one sustained attention task in a battery, as opposed to one task alone. The TEA-Ch is one such battery that is able to provide assessment of performance related to multiple components of attention.

Assessment with the TEA-Ch

With the introduction of the TEA-Ch by Manly, Robertson, Anderson and Nimmo-Smith in 1999, a new opportunity in research on children’s attention arrived in the field of attention assessment. The TEA-Ch is a battery of nine subtests of performance tasks, which have received commendation for having the appearance of games to children, which may increase effortful participation in assessment (Chan et al., 2008). Construction and psychometrics of the TEA-Ch
will be discussed later. Currently, the TEA-Ch is one of the only objective assessment batteries available that is designed to measure more than one construct of attention while excluding measurement of other constructs such as verbal skills and executive functioning (Heaton et al., 2001). The TEA-Ch appears to be sensitive to the measurement of sustained attention. Manly et al. (2001) administered the TEA-Ch to 24 boys diagnosed with ADHD who had never been medicated with stimulants. Compared to age and IQ matched controls, the boys with ADHD performed significantly worse on subtests related to sustained attention.

Subsequently, several other researchers have demonstrated similar discriminative properties of the TEA-Ch among children with and without attention problems. In the first study using the TEA-Ch in the United States, Heaton et al. (2001) noted that the TEA-Ch was able to significantly distinguish between a group of 63 children with ADHD and a non-clinical group of 23 children on subtests of sustained attention and attentional switching/control. Hood et al. (2005) found that when comparing a group of 15 children with ADHD with a group of 16 age, sex, and IQ-matched non-clinical children, the children with ADHD performed worse on subtests of sustained attention. In a similar study, Sutcliffe, Bishop, and Houghton (2006) found that a group of 18 children with ADHD when compared to a group of 18 non-clinical children performed significantly worse on subtests of sustained attention and attention switching/control. More recently, Chan et al. (2008), in an attempt to validate translated versions of the TEA-Ch in China, demonstrated a significant impairment of performance on subtests of sustained attention with a clinical group of 22 children with ADHD in comparison to a group of 22 non-clinical children. It appears that the subtests of the TEA-Ch have demonstrable ability to discriminate between children with and without ADHD. It follows then, that an objective measure of
attention such as the TEA-Ch with potential to discriminate between clinical and non-clinical groups has power in predicting the presence or absence of an ADHD diagnosis.

**Prediction and the TEA-Ch**

Two recent studies have investigated prediction with the use of the TEA-Ch (Preston et al., 2009; Verstraeten, Vasey, Claes, & Bijttebier, 2010). Preston et al. (2009) conducted a study investigating the ability of the TEA-Ch to predict academic difficulty in a sample of 45 children with ADHD. They supposed that the sustained attention component would be most predictive of academic impairment in children with ADHD, but discovered through regression analyses that performance on the attention switching component of the TEA-Ch was most predictive of impairment. Specifically, Preston et al. (2009) found that switching attention performance on the TEA-Ch was a stronger predictor of academic impairment than parent-completed rating scales of the children. In a different study, Verstraeten, Vasey, Claes, and Bijttebier (2010) compared the TEA-Ch along with several questionnaires purported to measure effortful control (a concept related to inhibition) to predict symptoms of psychopathology. Performance on the TEA-Ch and ratings of effortful control in 224 children demonstrated that the TEA-Ch was a significant predictor of psychopathology symptomatology, although less so than measures of effortful control. Verstraeten et al. (2010) concluded that measures related to effortful control may be better at assessing psychopathology in children than the TEA-Ch. Although neither of the preceding studies used TEA-Ch performance to predict a diagnosis of ADHD, it does seem that the TEA-Ch shows evidence of the ability to discriminate amongst children with various disorders.
Aim of the Present Study and Research Hypotheses

Aim of the Present Study

A variety of attention assessments have been used in diagnosing ADHD in children. Although subjective rating scales are the traditional method of assessment used to identify hallmark symptoms and problem behaviors, the availability of other forms of attention assessment has increased considerably in recent years. Few empirical projects have studied assessment of sustained attention in children, even though sustained attention is frequently cited as a key impairment in children with ADHD (Betts et al., 2006). Continuous performance task assessments may measure sustained attention, but their utility has been called into question and they offer results on one component of attention only (Heaton et al., 2001). The advantage of using the TEA-Ch is that it is reported to assess not only sustained attention, but also selective attention and attentional control and switching (Heaton et al., 2001; Manly et al., 2001). Further, a number of studies have shown the TEA-Ch to be able to discriminate well between children with and without attention problems (Chan et al., 2008; Heaton et al., 2001; Hood et al., 2005, Sutcliffe et al., 2006). Manly et al. (2001) suggested that accurate prediction is one of the key components of assessment. It appears that the TEA-Ch may have potential for predicting accurate ADHD diagnoses.

Although there appears to be increasing support for the ability of the TEA-Ch to differentiate between children with and without ADHD, this evidence does not directly translate into how to best utilize the TEA-Ch in clinical assessment. A complete TEA-Ch protocol generates 13 scaled scores but the authors (Manly et al., 1999) provide little guidance on interpreting these results. It is worth investigating children’s performance on subtests of the TEA-Ch so that scores on the TEA-Ch can be more meaningfully interpreted. Being able to discriminate between
ADHD and non-ADHD groups of children with the TEA-Ch is important, but it is also of interest to develop specific strategies for interpreting the TEA-Ch scores in a clinical setting.

**Hypotheses**

1. It is hypothesized that diagnostic status (diagnosis of ADHD with or without comorbid disorders (ADHD) versus no ADHD diagnosis with or without other disorders (NO/OTHER)) can be predicted from scores of three subtests of the TEA-Ch (Sky Search, Score!, and Opposite Worlds). Specifically, it is hypothesized that performance on the subtest related to sustained attention (Score!) will be a statistically significant predictor of diagnostic status.

2. It is hypothesized that the sustained attention component of the TEA-Ch will be a stronger predictor in relation to diagnosis as compared to the components of selective attention and attentional switching.

3. It is hypothesized that cut points for the sustained attention component of the TEA-Ch at -1 standard deviation (SD) and -2SD, will yield varying rates of correct identifications of the ADHD sample. These cut points are expected to differ in their clinical utility for making an ADHD diagnosis with one of the cut points being more advantageous than the other.

4. It is hypothesized that there will be a significant positive relationship between diagnosis and gender. Specifically, it is hypothesized that there will be an association between the ADHD group and boys and an association between the NO/OTHER group and girls.

5. It is hypothesized that there will be a significant negative relationship between diagnosis and age. Specifically, it is hypothesized that there will be an association between younger children and the ADHD group and an association between the NO/OTHER group with older children.
Method

Participants

Participants included in the current study were 166 children referred for behavior problems and/or learning concerns at an outpatient children’s mental health clinic in the Pacific Northwest region of the United States. The child participants ranged in age from 6 to 15 ($M = 9.18$, $SD = 2.08$) years old and were 76.5% male ($n = 127$) and 23.5% female ($n = 39$). The majority of the participants were Caucasian children from middle and upper-middle class families, but no specific racial or socioeconomic background data were collected for the purposes of this study.

Procedure

Participants were self-referred to the outpatient clinic due to academic, behavioral, and social-emotional concerns. As part of the referral process, each child participant had a psychoeducational evaluation including a parent or guardian interview conducted by a licensed clinical psychologist and either a behavioral pediatrician or a child psychiatrist. The participants were administered an intelligence test, subtests of an achievement test, and the TEA-Ch during their evaluations. Parents completed behavioral rating scales prior to arriving for the evaluations. Only the TEA-Ch evaluation data will be included the current study. The TEA-Ch was administered by a research assistant, under the supervision of a licensed clinical psychologist, in approximately the first hour of the 3-hour evaluation. The TEA-Ch was administered in the first hour of the evaluation for convenience so that the child could begin assessment while the parents or guardians were being interviewed. Because the TEA-Ch includes several subtests that take a considerable amount of time to administer, and in the interest of efficiency during the evaluations, children did not usually complete the entire battery. If a
child completed enough subtests that resulted in a noticeable pattern according to clinical judgment, testing might be discontinued. Parents or guardians of each child attended a family feedback session within 1 month after the evaluation to discuss diagnostic findings, implications, and recommendations. For the purposes of the current study, the data set included TEA-Ch evaluations conducted over a 3 year time period. This study was reviewed and approved by the Institutional Review Board at Pacific University.

Approximately 190 children’s test data were considered, but 1 participant who obtained a full scale intelligence score below 70 was excluded from the data set to eliminate any confounding of the results with lower cognitive functioning. Additionally, only children who completed at least three subtests of the TEA-Ch, including the Sky Search, Score!, and Opposite Worlds subtests, were included in the dataset. Performance on these tasks were used in the subsequent analysis. Because many children had not received the entire TEA-Ch battery for clinical reasons as noted previously, these criteria dropped the number of child participants from 190 to 166.

Measures

Predictor variables.

Demographics. Children’s age and gender were ascertained from the intake coordinator’s initial reports. These reports are generated when a parent or guardian calls to schedule an evaluation.

The Test of Everyday Attention for Children (TEA-Ch). The TEA-Ch is an objective measure of attention developed by Manly et al. (2001). The battery consists of nine subtests presented in a game-like format and include: Sky Search, Score!, Creature Counting, Sky Search DT, Map Mission, Score DT, Walk, Don’t Walk, Opposite Worlds, and Code Transmission,
which yield a total of 13 scaled scores. Subtests range in completion time from 2 to 12 minutes. The first four subtests can be used as a screening measure and the battery has alternate forms (A and B) to allow for re-test. Sky Search is a timed, visual search task that requires the examinee to search for matching pairs of stimuli among a page full of unmatched pairs of stimuli. The Score! subtest is an auditory task that requires an examinee to count a series of sounds, over 10 trials nearly equal in length. Creature Counting is a timed subtest in which an examinee must count stimuli forwards and backwards as directed by arrows on a page. Sky Search DT is a timed, dual task subtest in which an examinee must complete both the Sky Search and Score subtests simultaneously. Map Mission is another timed, visual search task subtest requiring an examinee to search for targets among a page of non-targets. The Score DT subtest is an auditory dual task in which examinees must complete the Score subtest while simultaneously listening for a target word in another auditory stimulus presented simultaneously. Walk, Don’t Walk is a subtest in which examinees track auditory sounds on a sheet and must stop once a target sound is presented. Opposite Worlds is a timed subtest of two trials in which an examinee reports simple visual stimuli as presented on a page, and then two trials of reporting the opposite of the visual stimuli presented on a page.

Performance on each of the nine subtests yields at least one scaled score ranging from 1 to 19 with a mean of 10 and standard deviation of 3. The Sky Search subtest yields three scaled scores (one related to accuracy, one related to completion time, and the other to both time and accuracy together), the Creature Counting subtest yields two scaled scores (one for accuracy, the other for completion time), the Opposite Worlds subtest yields two scaled scores (one for the regular reporting of stimuli, the other for the opposite reporting of stimuli), while the other six subtests
yield only one scaled score. Scaled scores resulting from the assessment are to be used to
determine a child’s attention strengths and weaknesses (Manly et al., 1999).

The TEA-Ch does not have composite scores corresponding to the three components of
attention, nor does it have an overall score. Manly and colleagues (1999) noted that
interpretation should be performed by analyzing patterns of strengths and weaknesses from
individual subtests and cautioned that their cognitive definition of attention may be different
from the behavioral definition of attention included in ADHD diagnostic criteria.

**Psychometrics of the TEA-Ch.** Manly and colleagues (2001) standardized the nine
subtests of the TEA-Ch battery with 293 healthy Australian children ages 6 to 15 years, 11
months. Test-retest reliability was assessed on the TEA-Ch through re-administration to 55
children between 5 and 20 days after the first administration. Test-retest correlations yielded
coefficients between .57 and .85, with all but 2 correlations above .70. Divergent validity was
assessed by correlating prorated IQ scores with all of the TEA-Ch subtests for 160 children in the
standardization sample, yielding only four significant correlations with TEA-Ch subtests.
Significant correlations of the four subtests were all below .31, suggesting that the attention tasks
were not measuring cognitive ability (Manly et al., 2001).

The authors purported to measure the convergent validity of the battery in two different
ways. Convergent validity of the TEA-Ch was assessed by correlating subtest performance in a
subset of 96 children from the normative sample with three tests purported to measure similar
types of task performance. The Stroop task (Trenerry, Crosson, DeBoe, & Leber, 1989) is
considered to tap selective attention and was most significantly correlated with the Sky Search
subtest. The two forms of the Trail Making Test are considered to tap selective attention and
attention switching (Spreen & Strauss, 1991), and were most significantly correlated with the
TEA-Ch subtests of selective attention, Sky Search and Map Mission, in addition to a subtest of sustained attention, Code Transmission. The Matching Family Figures Test, which is thought to measure response inhibition (Arizmendi, Paulsen, & Domino, 1981), was most significantly correlated with the TEA-Ch subtest measuring response inhibition, Creature Counting. However, it was also related to Score DT, a dual task subtest of sustained attention suggesting that response inhibition may be involved in multiple TEA-Ch subtests (Manly et al., 2001).

Finally, validity of the TEA-Ch was further assessed with a structural equation model, demonstrating that each of the nine subtests loaded onto only one of three hypothesized attention factors, selective attention, sustained attention, and attentional switching, with regression coefficients all above .44. Each of the nine subtests adequately mapped onto their related attention factor. The Sky Search and Map Mission subtests were most closely associated with the selective attention factor. The Creature Counting and Opposite Worlds subtests were most closely associated with the attention switching factor. Score!, Code Transmission, Walk, Don’t Walk, Score DT, and Sky Search DT were most closely associated with the sustained attention factor. The TEA-CH demonstrated relatively acceptable reliability and validity at the time of its release.

Scores from three (Sky Search, Score!, and Opposite Worlds) of the original 9 subtests will serve as the continuous predictor variables in the current study. One subtest was selected to measure each of the three components of attention. For the Sky Search (a selective attention task) subtest, only the combined accuracy and time scaled scores were considered because this score reflected both the speed and accuracy required in the task. The Score! (a sustained attention task) subtest results in one scaled score only. Opposite Worlds (an attention switching task) yields two scaled scores, one for each Stroop-like condition. Because both conditions
result in scaled scores that indicate better performance with higher scores, a sum of the scaled score for both conditions was used for this study. These subtests were chosen as predictors for the present study because each was deemed to be a good representation of one of three hypothesized attention factors. Sky Search, Score!, and Opposite Worlds were also the three subtests most likely to be administered during evaluation because the evaluating psychologists deemed these to be demonstrative of attention performance.

**Outcome variable.**

**Diagnosis.** Information on the child’s diagnosis was obtained from the child’s charts shortly after the family feedback sessions. Diagnoses were determined by consensus between the evaluating psychologist and the developmental pediatrician or the child psychiatrist. The evaluating professionals reviewed information gathered during the interview portion of the evaluations including developmental and/ or parental history for ADHD, behavior checklists from parents and teachers, and descriptions of current functioning. The referral question for many of the evaluations was whether or not a child had ADHD.

Final diagnoses of the child participants following evaluation were used as the dependent variable. Children who received a diagnosis of ADHD of any subtype with or without comorbid disorders were designated as ADHD while children who were given either no ADHD diagnosis or other disorders (i.e., Reading Disorder, Generalized Anxiety Disorder, Tic Disorder, etc.) were designated as NO/OTHER for the purposes of this study. Thus, diagnosis was considered as a dichotomous outcome variable of ADHD (evidence of any ADHD subtype with or without any other diagnosis) or NO/OTHER (no ADHD diagnosis with or without another diagnosis). It should be noted that many children were not given a diagnosis that included subtype
information; therefore, no specific analyses based on ADHD subtypes were possible for this study.
Results

All analyses were conducted using the SPSS (version 17.0) statistical software package. Prior to conducting the main analyses, the researcher screened the data for entry errors and missing data, and no cases were excluded for these reasons. Screening for outliers was done in accordance with a specific analytic technique discussed later.

The binary logistic regression used as the analytic procedure for the first two hypotheses has no assumptions of predictor variable distribution, linear relationship, or equal variances (Mertler & Vanatta, 2005). Complete data on all measured variables were available for all 166 cases. Participants in this data set were not randomly selected but rather were clinic-referred.

**Hypothesis 1: TEA-Ch Subtest Prediction of Diagnosis**

A binary logistic regression was conducted to assess if any of the three TEA-Ch subtest scores (Sky Search, Score!, and Opposite Worlds!) were significant predictors of diagnosis (ADHD or NO/OTHER). Subtests were included in the analysis using Method Enter. Scaled scores of the three subtests of the TEA-Ch were considered to be independent predictors of diagnosis for this analysis because completion of the individual tasks was not dependent on each other. Generally, 50 cases per predictor variable is recommended for logistic regression and this criteria was met for this study. A preliminary multiple regression analysis was used to screen the data for outliers, and no outliers were detected.

The results of the logistic regression analysis showed that none of the three subtests were significant predictors of diagnosis. None of the subtests independently or in combination accurately predicted diagnostic group (-2 Log Likelihood = 187.28; \( \chi^2(3) = 2.456, p = .483 \)), and overall model fit was poor. Both Cox and Snell’s \( R^2 \) of .015 and Nagelkerke’s \( R^2 \) of .022 indicated that very little of the proportion of variability in diagnosis was accounted for by
performance on the three subtests. Thus, less than 3% of the variance in diagnosis was accounted for by the TEA-Ch subtests. The resultant model was weak at accurately classifying cases, as 100.00% of the ADHD cases were predicted correctly, and none of the NO/OTHER diagnosis cases were predicted correctly. Although the model appears to have extremely high accuracy in predicting ADHD, the model was of little predictive value in accurately predicting cases without ADHD correctly. The logistic regression coefficients for the analysis are presented in Table 1. The Wald statistics demonstrated that none of the subtests were significant predictors of diagnosis, and the odds ratios for the predictors were relatively small, indicating a low probability of diagnosis. In summary, hypothesis 1 was not supported as the TEA-Ch subtests were not significant predictors of diagnosis.

Table 1

Regression Coefficients for Subtest Predictors of Diagnosis

(N=166)

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>$Wald$</th>
<th>$df$</th>
<th>$p$</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sky Search</td>
<td>.04</td>
<td>.34</td>
<td>1</td>
<td>.56</td>
<td>1.04</td>
</tr>
<tr>
<td>Score!</td>
<td>-.02</td>
<td>.10</td>
<td>1</td>
<td>.75</td>
<td>.98</td>
</tr>
<tr>
<td>Opposite Worlds</td>
<td>-.05</td>
<td>1.90</td>
<td>1</td>
<td>.17</td>
<td>.95</td>
</tr>
<tr>
<td>Constant</td>
<td>1.71</td>
<td>5.12</td>
<td>1</td>
<td>.02</td>
<td>5.51</td>
</tr>
</tbody>
</table>
Hypothesis 2: TEA-Ch Attention Components Prediction of Diagnosis

It was hypothesized that performance on the sustained attention component of the TEA-Ch, the Score! subtest, would be a stronger predictor of diagnosis in contrast to performance on the subtests of selective attention and attention switching. Given that the results of the binary logistic regression used for Hypothesis 1 indicated that none of the subtests were accurate predictors of a diagnosis of ADHD, Hypothesis 2 was not supported. Sustained attention did not appear to be a better predictor of diagnosis relative to the other two components of attention.

Additional Analyses: Diagnostics of TEA-Ch Subtest Prediction

Because the results from the binary logistic regression in Hypotheses 1 and 2 demonstrated that none of the subtests were significant predictors of diagnostic status, follow-up analyses were conducted to probe the nature of the results and to verify that the relations among the variables were valid. These additional analyses were designed to eliminate and/or identify factors that could have attenuated the strength of the predictors in Hypotheses 1 and 2. Frequency bar graphs were created for each of the three TEA-Ch subtests, yielding a relatively normal distribution of scores within the sample. Thus, it is not likely that the absence of significant relations in the logistic regression analysis can be explained by range restriction of scores on the subtests nor by the presence of extreme scores on the subtests.

Bivariate scatter plots also indicated that performance on each of the three subtests was distributed evenly across diagnostic groups. This indicates that poor prediction of the subtests was likely not accounted for by unusual patterns of performance in either the ADHD group or the NO/OTHER group. Further, an additional bivariate scatter plot of performance on the selective and sustained attention subtests demonstrated very little relationship between these two
variables. This result is discussed later in an additional analyses section on relations of age, gender, and the TEA-Ch subtests.

**Hypothesis 3: TEA-Ch Attention Components Cut Points**

It was hypothesized that scores on the subtests of the TEA-Ch could be used to accurately identify children with and without an ADHD diagnosis. Given that the TEA-Ch scoring does not provide any information that can be used as a cutoff score for assigning a diagnosis, cut point scores were created to address this question. Two different cut points were created for this set of analyses. The first cut point was established at -1 standard deviation below the mean such that children scoring below a 7 on the subtest were considered to have scored in the low range and children scoring above a 7 were considered to be in the typical range. A second cut point was established at -2 standard deviations below the mean such that children scoring below a 4 on the subtest would be considered to have scored in the low range and children above 4 would be considered in the typical range. Cut points were then used to determine percentages of the sample for whom: 1) the child scored low on the subtest and was given an ADHD diagnosis (Group Correct Hit), 2) the child scored low on the subtest and but was not given an ADHD diagnosis (Group Error I) 3) the child scored typical on the subtest and was given an ADHD diagnosis (Group Error II), and 4) the child scored typical on the subtest and was not given an ADHD diagnosis (Group Correct Rejection). Figures and percentages of accurately identified cases of ADHD using the cut points are presented in Table 2. It was expected that low performance on the sustained attention component would yield the most accurate identification of the ADHD group. The results indicated, however, that typical performance on each of the attention components, including the sustained attention component, yielded the highest
percentages of correctly identified children. As expected, the -2 SD cut point yielded more percentages of correctly identified children than the -1 SD cut point.

Because it would be generally expected that children without ADHD would perform better on tasks related to attention, it was expected that typical performance on each of the attention components would yield the highest percentages of accurately identified children in the NO/OTHER group in contrast to the ADHD group. Although it was expected that the sustained attention component cut points would best identify children in both groups, it was actually the attention switching component that identified the most cases in each group accurately.
Table 2

*Cut Point Figures and Percentages of Typical and Low Performance on Attention Components*

*(ADHD \(N=124\); NO/OTHER \(N=42\))*

<table>
<thead>
<tr>
<th></th>
<th>ADHD -1 SD</th>
<th></th>
<th>ADHD -2 SD</th>
<th></th>
<th>NO/OTHER -1 SD</th>
<th></th>
<th>NO/OTHER -2 SD</th>
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<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Sustained Attention Low</td>
<td>53</td>
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<td>15</td>
<td>35.74</td>
<td>12</td>
<td>9.68</td>
<td>3</td>
<td>7.14</td>
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<tr>
<td>Sustained Attention</td>
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<td>58.68</td>
<td>27</td>
<td>64.29</td>
<td>112</td>
<td>90.32</td>
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<tr>
<td>Typical</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Selective Attention Low</td>
<td>39</td>
<td>31.45</td>
<td>17</td>
<td>40.48</td>
<td>17</td>
<td>13.71</td>
<td>2</td>
<td>4.76</td>
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<tr>
<td>Selective Attention</td>
<td>85</td>
<td>68.55</td>
<td>25</td>
<td>59.52</td>
<td>107</td>
<td>86.29</td>
<td>40</td>
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</tr>
<tr>
<td>Attention Switching Low</td>
<td>48</td>
<td>38.71</td>
<td>15</td>
<td>35.71</td>
<td>11</td>
<td>8.87</td>
<td>1</td>
<td>2.38</td>
</tr>
<tr>
<td>Attention Switching</td>
<td>76</td>
<td>61.29</td>
<td>27</td>
<td>64.29</td>
<td>113</td>
<td>91.13</td>
<td>41</td>
<td>97.62</td>
</tr>
</tbody>
</table>
Additional Analyses: Relationship between Diagnosis and TEA-Ch Subtest Performance

Although not originally hypothesized, three independent-samples $t$-tests were conducted to evaluate whether or not the NO/OTHER group performed significantly better than the ADHD group on the subtests of the TEA-Ch. Because ADHD is generally thought of as a disorder of sustained attention, it was expected that the mean for ADHD group would be significantly lower on the sustained attention subtest than the NO/OTHER group. The results indicated that there was no significant difference on the sustained attention subtest between the two groups, $t(165) = .13, p = .90$ (see Table 3). Similarly, the $t$-tests for the selective attention subtest, $t(165) = -.71, p = .48$ and the attention switching subtest, $t(165) = -1.42, p = .16$, were also nonsignificant indicating no real differences in performance between the ADHD group and the NO/OTHER group.

Table 3

*Group Means, Standard Deviations, and Sample Sizes for TEA-Ch Subtests*

<table>
<thead>
<tr>
<th>TEA-Ch Subtest</th>
<th>Sky Search</th>
<th>Score!</th>
<th>Opposite Worlds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Diagnostic Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHD ($N = 166$)</td>
<td>8.21</td>
<td>2.94</td>
<td>8.94</td>
</tr>
<tr>
<td>NO/OTHER ($N = 42$)</td>
<td>8.14</td>
<td>2.81</td>
<td>9.38</td>
</tr>
</tbody>
</table>
Hypotheses 4 and 5: Relationships between Gender, Age, and Diagnosis

Pearson product moment correlations were computed among gender, diagnosis, age, and the three TEA-Ch subtests (see Table 4). It was hypothesized that gender would be positively related to diagnosis such that more males would be diagnosed with ADHD than females. This hypothesis was supported as there was a significant positive correlation between gender and diagnosis, \( r(164) = .20, p = .01 \). It should be noted that although this relation was statistically significant, the effect was small in magnitude.

It was also hypothesized that age would be negatively related to diagnosis. The analysis indicated that a significant negative relationship existed, \( r(164) = -.15, p = .05 \). This finding indicates that the ADHD group was younger than the NO/OTHER group. Again, caution is warranted in interpreting this finding as the effect size was small in magnitude.

Additional Analyses: Relationship between Age and Gender and between the TEA-Ch Subtests

Additional Pearson product moment correlations were conducted between age and gender, as well as between the attention components of the TEA-Ch. Given that these relations were not originally hypothesized, a Bonferroni correction was applied. To control for Type I error across the 15 correlations, a Bonferroni adjustment with a p-value less than .003 (\( .05/15 = .003 \)) was used to determine significance. This correction resulted in three statistically significant relationships, all small in magnitude (see Table 4). There was a significant negative relationship between age and gender, \( r(164) = -.23, p < .003 \), indicating that in this sample, older children tended to be girls while younger children tended to boys. There were two significant positive correlations related to the attention switching subtest, Opposite Worlds, one with the selective attention subtest, Sky Search, \( r(164) = .30, p < .003 \), and the other with the sustained
attention subtest, Score!, \( r(164) = .28, p < .003 \). These results suggest that attentional switching may require some elements of both selective and sustained attention. In contrast, the selective and sustained attention tasks were not significantly correlated with each other suggesting that they may be relatively distinct tasks that do not tap the same construct of attention.

Table 4

*Means, Standard Deviations, and Bivariate Correlations among Age, Gender, Diagnosis, and TEA-Ch Subtest Scores*

\((N = 166)\)

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>Gender</td>
<td>-</td>
<td>.20</td>
<td>-.23*</td>
<td>-.09</td>
<td>-.01</td>
<td>.08</td>
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<tr>
<td>Diagnosis</td>
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<td>-.15</td>
<td>.01</td>
<td>-.06</td>
<td>-.11</td>
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<tr>
<td>Age</td>
<td>-</td>
<td>.08</td>
<td>-.11</td>
<td>-.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sky Search</td>
<td>-</td>
<td>.07</td>
<td>.30*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Score!</td>
<td>-</td>
<td>.28*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Opposite Worlds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Mean                  | 9.18   | 8.19      | 9.05 | 16.34|
| SD                    | 2.08   | 2.90      | 3.52 | 5.80 |

*\(p < .003\)
Discussion

Review of the Findings

The purpose of the current study was to increase the utility of an objective measure of children’s attention, specifically, the TEA-Ch, by demonstrating the predictive value of this test in diagnosing Attention-Deficit/Hyperactivity Disorder (ADHD). Given that previous research has highlighted a need for objective assessment of ADHD and has indicated that other objective measures of attention available may be problematic (Heaton et al., 2001), the TEA-Ch may fill a necessary clinical niche in assessing attention. In the context of the limited empirical literature on the TEA-Ch, some studies have shown the ability of this measure to differentiate between children with and without ADHD. If the TEA-Ch is able to clearly distinguish between groups based on performance, it may be that performance on this measure can be used to predict diagnoses of ADHD. Currently, the clinical utility of the TEA-Ch is limited by its psychometric properties including a lack of composite scores. This study sought to demonstrate the potential for the TEA-Ch subtests to be used as predictors of the presence or absence of ADHD. Additionally, it was anticipated that other analyses of TEA-Ch performance (e.g., cut points, relationships between subtests and participant characteristics) might result in additional meaningful ways to interpret scores.

Major Findings

Hypothesis 1: TEA-Ch subtest prediction of diagnosis. It was hypothesized that performance on the subtests of the TEA-Ch would be significant predictors of diagnostic status. Contrary to expectation, the three TEA-Ch subtests were not useful predictors (accounting for less than 3% of the variance) of diagnosis in this study. The resultant model of prediction indicated that none of the subtests, including the sustained attention task, were good predictors of
diagnosis with 100% of the ADHD cases being identified correctly, but none of the NO/OTHER cases being correctly predicted. This is problematic in that prediction of dichotomous outcomes with high accuracy of only one of the outcomes but not the other has little diagnostic utility. In layman’s terms, this would be synonymous with a weather man being able to predict sunshine 100% of the time while never being able to predict rain accurately which would hardly ever result in a useful forecast. Without being able to accurately predict the absence of ADHD, accurate identification of ADHD cases becomes a moot point.

The finding that that the TEA-Ch subtests did not significantly predict the outcome variable is in contrast to other empirical studies. Two other recent studies have been able to demonstrate TEA-Ch subtests as significant predictors of academic achievement (Preston et al., 2009) and psychopathology symptoms (Verstraeten et al., 2010). Given the TEA-Ch’s ability to predict psychopathology, it would be expected that the TEA-Ch would significantly predict ADHD also. There are several reasons that may account for these differences. It may be that because this study included a clinic-referred sample, the TEA-Ch may not be sensitive enough to nuances between the ADHD and NO/OTHER group. Even children without a final ADHD diagnosis in this sample were likely exhibiting some noticeable learning and/or behavioral problems that prompted referral for psychoeducational evaluation, and so may not be substantially different enough in comparison to their diagnosed ADHD peers. Further, while some of the children in the NO/OTHER group may have had disorders other than ADHD, others may simply have exhibited subclinical levels of attention problems that did not warrant a diagnosis of ADHD. The underlying attention problems that may have existed within the NO/OTHER group may have made it difficult to distinguish it clearly from that of the ADHD group, at least with TEA-Ch scores. Utilizing a comparison sample of children whom were not
referred may have increased the differences between the groups. In summary, the lack of a more distinguishable community control group may have lowered the strength of prediction.

**Hypothesis 2: TEA-Ch attention components prediction of diagnosis.** In accordance with the results from Hypothesis 1, this hypothesis was not supported because the sustained attention component was not a significant predictor of diagnostic status. It was expected that the sustained attention component would yield the most accurate prediction among the other subtests because sustained attention has been demonstrated to be a key impairment in children with ADHD.

**Hypothesis 3: TEA-Ch attention components cut points.** Cut points were established for the TEA-Ch subtests to investigate the possibility that this strategy could lead to accurately identifying children with ADHD and NO/OTHER diagnoses. It was expected that low performance on the three attention components would yield the highest accurate identification when compared to typical performance on the TEA-Ch, and specifically that the sustained attention component, might be most useful in doing so. Contrary to expectation, however, typical performance on the subtests yielded the highest accuracy of diagnostic identification, and the attention switching component yielded better identification of cases, with 91.13% of the ADHD group and 97.62% of the NO/OTHER group correctly identified under the -2 standard deviation condition. This finding is consistent with Preston et al. (2009) who discovered that the attention switching/control component resulted in the best predictor for the purposes of their study as compared to the sustained attention component. It may be that the attention switching component, not the sustained attention component has greater utility in distinguishing between groups.
To this researcher’s knowledge, no other studies have attempted to use a method to transform scores on the TEA-Ch to enhance interpretation of results. Nigg (2005a) has commented that the possible heterogeneity of ADHD in children may contribute to the common occurrence of nonsignificant findings in studies of attention assessment with small sample sizes. It has been suggested that separating children with ADHD into groups of typical and low performance may illuminate other factors associated with performance between the groups (Nigg, 2005a). Although this strategy was technically employed here, other possible external factors related to performance in the subgroups were not analyzed.

**Additional analyses: Relationship between diagnosis and TEA-Ch subtest performance.** Although not part of the original hypotheses, it was determined that there were no significant differences on mean subtest performance between the ADHD group and the NO/OTHER group. It was expected that the NO/OTHER group would perform significantly better than the ADHD group on each of the subtests, but results indicated that this was not the case. The NO/OTHER group did score slightly higher than the ADHD group on both the sustained and attention switching subtests, but differences were small and not significant. Again, the possible overlap in symptomatology between the two groups of children may have been implicated such that noticeable differences in performance could not be detected by the TEA-Ch.

**Hypotheses 4 and 5: Relationships between gender, age, and diagnosis.** It was hypothesized that there would be a significant positive relationship between gender and diagnosis, and a significant negative relationship with age and diagnosis. Both of these relations were supported. This indicated that as expected, children with ADHD in a clinic-referred sample tended to be younger and male, in contrast to NO/OTHER children, who tended to be older and female. Similar findings of clinic-referred children have been well documented in the literature
Although not part of the original hypotheses, a significant relation between age and gender indicated that in the sample of the current study, younger children tended to be boys and older children tended to be girls. Again, this is a common representation of clinic-referred children. Barkley (2003) has commented that this occurrence is likely related to the fact that young boys tend to exhibit more troubling externalizing behavior than young girls. Young boys tend to receive more clinic referrals for these issues than young girls who may not demonstrate noticeable behavior problems until they are appreciably older (Barkley, 2003).

Additional Analyses: Relations between the TEA-Ch subtests. Additional significant relationships were also established between the TEA-Ch subtests. While the selective and sustained attention components were not significantly correlated, both components were significantly related to the switching attention component. This finding is in line with the structural equation modeling used with the normative sample of the TEA-Ch. The structural equation modeling proffered by Manly et al. (1999) demonstrated that a smaller link exists between the selective and sustained attention components than exists between these two components and the switching component. Chan et al. (2008) conducted a confirmatory factor analysis of the Chinese version of the TEA-Ch with children in China and were able to replicate Manly et al.’s three-factor model. In that study, the selective attention and sustained attention components were also more closely related to the switching attention component than to each other.

Conclusion

This study attempted to both demonstrate the strength of objective measures of children’s attention and to enhance the clinical utility of the TEA-Ch by using subtest performance as an indicator of diagnosis. Despite the fact that the neither of the hypotheses related to subtest
prediction nor the hypothesis related to performance cut points were supported, some interesting results were found. The typical ADHD clinic-referred population was relatively well represented in the present study. Participants were mostly male and younger rather than older. The children who received a diagnosis of ADHD were mostly male and younger than children in the NO/OTHER group who tended to be older and female.

The sustained attention component of the TEA-Ch was hypothesized to be better at predicting and differentiating ADHD than other subtests based on literature suggesting that sustained attention may be the demonstrable impairment in ADHD (Hood et al., 2005). However, this was not the case in this study. It was the attention switching component that served as both a better identifier of diagnosis in the cut point analysis and was significantly related to the selective and sustained attention components. Hood et al. (2001) and Manly et al. (2001) both found that poor performance on the sustained and switching components of the TEA-Ch differentiated children with and without ADHD. The results from the current study related to switching attention appear to be somewhat in line with TEA-Ch performance results elsewhere. It may be that sustained attention and switching attention are the main components impaired in children diagnosed with ADHD.

Limitations

Methodology. Several methodological issues limit the findings of the current study. Because this study included a clinical sample of convenience, a true control group was not employed for comparison. A quasi-control group, the NO/OTHER group, was utilized, but the children in this group were also a referred sample and likely had behavioral and/or learning problems salient enough to warrant a referral to an outpatient children’s mental health clinic. This study used a simple differentiation between the presence of any type of ADHD and the
absence of a clinical diagnosis of ADHD. Although not addressed in this study, the majority of the NO/OTHER children were diagnosed with learning disorders or other mental health disorders. Including comorbidity of other diagnoses without additional, subsequent analyses of specific diagnostic status clouds the interpretation of prediction from subtest performance. It could be that the subtests may have assessed attentional problems related to psychopathology in general which prevented good prediction between the ADHD and the NO/OTHER groups. This interpretation would be consistent with the results of the Verstraeten et al. (2010).

Regarding how testing was performed for this study, some evaluation practices may have played a role in the lack of significant results. For example, children were administered the TEA-Ch during the first hour of a 3-hour evaluation in a quiet, one-on-one, novel environment. These testing characteristics may have provided optimal conditions for children to be motivated to put forth their best effort and pay attention to the tasks, which could have led to decreased sensitivity to some of the more subtle attention deficits that children in the sample possessed. Because the children included in the sample were clinic-referred, the practical nature of real-life evaluations may have attenuated the results. Efficiency in evaluations is often necessary, and most of the children included in the sample did not receive a full TEA-Ch battery because testing on this measure was often discontinued after obtaining a sampling of subtests from each of the attention domains. In doing so, the time in the evaluation could be maximally used to administer other assessments related to the referral question.

The construction of the TEA-Ch may have also played a role in the nonsignificant results. For example, some children whom were not included in the sample of the present study did not receive the three subtests used here because they had difficulty understanding them or completing them correctly. This procedure may have eliminated children who would have
performed poorly, thus restricting the range of the test scores. While it is supposed that most children within the present study understood the tasks they were administered from the TEA-Ch, it is possible that some children’s performance was not optimal because they did not have a complete understanding of task directions. Furthermore, it is possible that TEA-Ch tasks may not have been challenging enough for the oldest children completing the test. Verstraeten et al. (2010) suggested that this phenomenon may have limited the variability in performance leading to weaker correlations between performance and other variables in their study.

The sample size for the current study with a clinic-referred population was adequate with a total of 166 children. Conducting a logistic regression has many advantages, such as being particularly useful in research with a dichotomous outcome like a diagnosis, and being free from assumptions of normality. A logistic regression analysis can also be limiting because it is intended to calculate probability estimates, and sample sizes must be relatively large. It is generally suggested that there be at least 50 cases per predictor. The results could possibly have shown more about diagnostic status prediction if there had been more variability in the information gained from each predictor.

**Generalizability.** The findings from the current study are likely to be relatively generalizable to clinical populations similar to the sample used. The majority of the children included in this study were Caucasian boys and from middle to upper class families. This is typical of the clientele frequenting outpatient child mental health services in private practice settings. Thus, sample characteristics and the size of the sample were not the main reasons for the lack of findings in this study. In terms of the results demonstrated here, it is likely that they would apply to similar settings elsewhere.
If the results from this study were compared to settings much different than the typical clinic-referred population described above, it might not be expected for findings to be similar to those here. Although it is difficult to speculate specifically how the results might differ if the sample were much different, Barkley (2003) remarked that ADHD is prevalent across all socioeconomic strata, but noted that ethnic and cultural differences of ADHD documented in the U.S. may not be associated if controlled for by socioeconomic differences.

**Future Directions**

**Improvements.** The methodology of the current study could certainly be improved upon in future research. Albeit that the current study was not able to demonstrate that subtests of the TEA-Ch were good predictors of diagnosis, two other studies have found that TEA-Ch subtests have been significant predictors of other clinical problems (Preston et al., 2009; Verstraeten et al., 2010). A larger sample size in the study would allow for inclusion of more and multiple types of predictors, especially all subtests of the TEA-Ch. The addition of other scores on other measures, such as subjective behavioral rating scales, IQ measures, and academic achievement measures as predictors could enhance predictions of an ADHD diagnosis because they may better highlight patterns of performance. The analysis may have been improved if any number of ADHD characteristics (i.e., subtype, specific comorbid disorders, age bands, medication response, etc.) were included. It is also possible that if every child had been administered a full TEA-Ch battery, subtests other than the ones selected by the researcher may have served as better predictors of diagnosis. Sutcliffe et al. (2006) recommended that future research with the TEA-Ch also include larger sample sizes and use the full battery.

**Next Steps.** Because the current study highlighted the growing interest in objective measures of assessment, future research might focus on a comparison of the TEA-Ch and a
continuous performance task battery. This comparison could prove useful if one method over the other significantly better predicted the presence and absence of an ADHD diagnosis. Research on objective assessment (as opposed to subjective assessment) of attention is still relatively in its nascent stages.

It would be useful, as Nigg (2005b) suggested, if a combination of neuropsychological theories and or measures could be employed within the one study. This might allow investigators to see differences across and within subgroups of ADHD, as well as to refine existing theories to best represent elements of the disorder. The current study found a pattern of attention components within the TEA-Ch similar to that of other studies. Future research might use both the TEA-Ch and another objective attention measure (based on a similar, yet different theory), such as the Attention Network Test (ANT) adapted for children (Rueda et al., 2004) within the same study to compare and contrast results between groups of ADHD children.

**Replication.** Although it is clear that several methodological elements could be improved upon in future research, and there are numerous possibilities for future research around this topic, it may not be necessary to replicate this exact study. The sample was relatively representative of a clinic-referred population according to sex, age, and diagnostic characteristics. It appears that expanding upon or changing the methodological design would be more important than replicating this exact study, as it does not appear that different findings would result without altering some of the variables.

**Contributions**

The results from this study added to the body of literature currently available on the TEA-Ch. To date, the body of published empirical studies using the TEA-Ch is small. Only a
handful of papers (e.g., Preston et al., 2009; Verstraeten et al., 2009) have investigated the predictive value of the TEA-Ch. Given that the TEA-Ch has been lauded as a good measure of children’s attention (Heaton et al., 2001), it would be unfortunate for its use to decline solely based on the absence of overall scores to help make inferences about performance.

Additionally, the current study demonstrated that traditional gender and age characteristics of a clinic-referred sample may still be representative of this population. Some of the recent literature has noted that gender and age characteristics in children with ADHD may actually differ substantially from what was reported in early traditional clinic-referred samples (Ramtekkar et al., 2010). It is still the case that ADHD diagnoses tend to be associated with younger, male children as compared to children who are older and female in clinic populations.

The current study, like the Preston et al. (2009) study, found some interesting results relating to the attention switching component of the TEA-Ch, when in both studies it was hypothesized that the sustained attention component would provide the most telling results. Preston et al. (2009) found the attention switching component was a significant predictor of academic difficulties in children with ADHD. Similarly, in the current study, the switching attention component of the TEA-Ch was found to yield the highest percentage of correctly identified cases of children with and without an ADHD diagnosis.

Because the current study was able to demonstrate TEA-Ch attention component relations similar to the three-factor models of Chan et al. (2008) and Manly et al.’s (2001) work, it contributes additional support to validity of the three-factor model of the TEA-Ch. This evidence toward the strength of the three-factor model of attention could be used in new research in accordance with Nigg’s (2005b) recommendation to combine measures and theories within one study by comparing the TEA-Ch and a different three-factor model, or perhaps a model with
a different number of factors, or with models containing very different factors of attention other than selective, sustained, and switching.
References


