MULTIDIMENSIONAL ASSESSMENT OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

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ABSTRACT

The present study examined the clinical utility of direct measures of neuropsychological performance (*Pediatric Attention Disorder Diagnostic Screener Target Tests of Executive Functioning, Wide Range Assessment of Memory and Learning-Second Edition, Trail Making Test-Part A/B)* and indirect measures of behavioral functioning (*Behavior Rating Inventory of Executive Function (BRIEF)-Parent and Teacher Form*) in the identification of children at risk for Attention Deficit-Hyperactivity Disorder (ADHD). The sample consisted of 80 elementary-aged children (6-12 years old), 40 ADHD and 40 Non-ADHD subjects, referred to a large community private practice setting in the Southern United States. Two sample *t*-tests (with Bonferroni correction) and effect sizes (Cohen's *d*) were computed to assess statistical and practical performance differences between ADHD and Non-ADHD groups. Youth in the ADHD group performed significantly worse on direct neuropsychological measures, yielding lower mean scale scores on all TTEFs, 3 of 4 WRAML-2 indices, and TMT-Part B than youth in the Non-ADHD group. Group differences were not found for the BRIEF Parent and Teacher Forms. Implications of findings for research and practice are presented.

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CHAPTER I

Purpose of the Study

Children suspected of having an attention disorder require comprehensive assessments that incorporate neuropsychological and behavior data that in turn inform diagnostic decision making and aide in effective intervention planning. Leading researchers in the field of Attention-Deficit/Hyperactivity Disorder (ADHD) endorse the use of a multi-method and multi-source assessment approach that integrates neuropsychological performance measures and parent and teacher behavior rating scales that tap attention, planning, organization, and working memory domains (e.g., Barkley, 1997; Barkley & Murphy, 2006; Reddy, Weissman, & Hale, 2013). However, practitioners tend to rely on behavior rating scales as the primary source of clinical information in the assessment of childhood ADHD. Given this gap between research and practice, it is critical to examine current assessment practices in the field of pediatrics and child psychology, and examine the clinical use of direct measures of neuropsychological performance and indirect measures of behavioral functioning in the assessment and evaluation of childhood ADHD.

The current study examined the clinical utility of direct measures of neuropsychological performance and indirect measures of behavioral functioning used in the identification of childhood ADHD. The primary objective of the present investigation was to compare the neuropsychological and behavioral score profiles of 80 elementary-aged children (e.g., 40 ADHD subjects and 40 Non-ADHD subjects) referred to a large private practice setting in the Southern United States.

CHAPTER II

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent and chronic developmental disorders that affects 3 to 7% of school-aged children (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007) and 5% of adolescents and adults (Curatolo, 2005; Faraone, Sergeant, Gillberg, & Biederman, 2003). Childhood ADHD causes significant impairments in educational, family, and peer functioning (Barkley, Fischer, Smallish, & Fletcher, 2004, 2006; Molina & Pelham, 2003).

Substantial research has illustrated the neurological, genetic, and environmental causes of ADHD, however, currently, no one factor has been determined as the primary cause of the disorder (Sims & Lonigan, 2012). Increasing evidence has pointed to the biological etiology of ADHD (Barkley, 1998; 2000) with family and twin studies showing a heritability of .8, higher than any other psychiatric disorder (Levy, Hay, McStephen, Wood, & Waldman, 1997). Neuroimaging studies of children and adults with ADHD illustrate abnormalities in the structure and functioning of the frontal regions in the brain that regulate attention and motor intentional behaviors (e.g., Castellanos et al., 1994; Filipek, Semrud-Clikeman, Steingrad, Kennedy, & Biederman, 1997; Giedd et al., 1994; Semrud-Clikeman et al., 1994; Zametkin et al., 1990). More specifically, children with ADHD demonstrate dysfunction in the frontal-subcortical circuits, which is associated with poor executive control of attention, inhibitory, and motor systems (e.g., Dickstein, Bannon, Castellanos, & Milham, 2006; Goldberg, 2001; Loo & Barkley, 2005; Makris et al., 2007; Mostofsky et al., 2002; Roth & Saykin, 2004; Vaidya et al., 2005).

ADHD is also widely associated with deficits in executive functions. Contrary to popular belief, executive functions (EFs) are separable but interrelated processes, as opposed to one unitary function (Gioia & Isquith, 2004; Pennington & Ozonoff, 1996). Executive functions are goal-directed neurocognitive processes that include planning, inhibition, flexibility, organized search, self-monitoring, and working memory (Baddeley, 1986; Goldman-Rakic, 1987; Pennington, 1994) that foster effective problem solving for attaining future goals (Welsh & Pennington, 1988).

Individuals with ADHD display significant impairments in key executive function domains including inhibition (e.g., Nigg, 2001; Pennington & Ozonoff; 1996), shifting (Oades & Christiansen, 2008; van Mourik, Oosterlaan, & Sergeant, 2005), planning (Barkley, 2003; Solanto et al., 2007), and working memory (Barkley, 2006; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Wilcutt, Pennington, Chhabildas, Olson, & Huslander, 2005). As a result, children with ADHD consistently perform worse on cognitive and executive function measures compared to non-ADHD peers (Pennington & Ozonoff, 1996). Biederman and colleagues (2004) found that children and adolescents with ADHD and deficits in executive functioning were at an increased risk for grade retention, learning disabilities, and lower academic achievement.

Although ADHD is currently conceptualized as a heterogeneous disorder rooted in neurobiological etiology, current diagnostic criteria and assessment practices continue to rely on the behavioral indicators of the disorder (Sonuga-Barke, 2002, 2003, 2005; Coghill et al., 2005). For example, in the *Diagnostic and Statistical Manual for Mental Disorders-Fourth Edition-Text Revision* (DSM-IV-TR; American Psychological Association, 2000), ADHD criteria is based solely on overt, behavioral symptoms, attributing little to the etiology of the condition (Pritchard, Nigro, Jacobsen, & Mahone, 2012). Not surprisingly, the assessment of ADHD also focuses on the observable and behavioral manifestations in order to meet DSM criteria for one of the three subtypes of ADHD: Predominately Inattentive, Predominately Hyperactive-Impulsive, or Combined Type. Current DSM-IV-TR criteria also emphasize the symptoms of inattention, while emerging literature across a lifespan provides strong evidence for core deficits in self-regulation and executive functioning (Barkley & Murphy, 2006). The current edition of the DSM fails to outline assessment procedures and specify objective instruments for use in the evaluation of ADHD (Baron, 2004). As a result, researchers and practitioners alike tend to rely on clinical interviews or behavior rating scales that target the “yes or no criteria” outlined in the DSM, which may or may not correlate with other assessment procedures (Widiger & Clark, 2000). In addition, the DSM also lacks adequate consideration of the developmental nature of many childhood disorders (Pritchard et al., 2012), and applies similar diagnostic criteria regardless of the patient’s age, gender, and course (Achenbach, 2005).

What the DSM fails to include, the American Academy of Pediatrics makes up for in their revised clinical practice guidelines for the diagnosis, evaluation, and treatment of ADHD in children and adolescents (AAP, 2011). According to the AAP guidelines, a primary care clinician should initiate an ADHD evaluation for a child or adolescent between the ages of 4 and 18 that presents with inattention, hyperactivity, impulsivity, academic underachievement, and/or behavior problems. At least half of individuals with ADHD are identified and treated by primary care physicians, not mental health professionals (Epstein et al., 2008; Leslie et al., 2006; Leslie et al., 2004). Direct evidence should be obtained from parents/caregivers as well as teachers regarding the core ADHD symptoms, age of onset, duration of symptoms, and degree of functional impairment across multiple settings. Lastly, the AAP also emphasizes the assessment of coexisting conditions (i.e., Conduct Disorder/Oppositional Defiant Disorder, Depression, Anxiety, and Learning Disabilities). The AAP also developed a “process of care algorithm” to provide primary care clinicians with discrete steps as a guide that directly relates to each of their key action statements outlined in the clinical practice guideline. Given that that this algorithm is based on the practical experience and advice of clinicians proficient in the diagnosis and management of ADHD in children and adolescents, it serves as an informal guideline in the identification and screening a child/adolescent for ADHD (See Figure 1).

Although assessment guidelines and criteria are widely available and accessible, no single tool has been identified as the ‘gold standard’ in the evaluation of childhood ADHD (Sims & Lonigan, 2012). Several research paradigms have also been employed to determine which standardized psychological and neuropsychological instruments are the most useful in the diagnosis of ADHD, however, no definitive evaluation protocol has emerged as the most effective (Gordon & Barkley, 1990). As such, this may explain why the clinical assessment of ADHD varies so greatly from one clinician to another (Frazier, Demaree, & Youngstrom, 2004) as well as across disciplines (i.e. school psychologists, neuropsychologists, clinical psychologists, and pediatricians).

Research indicates that 77% of primary care physicians are familiar with AAP guidelines, and 61% report incorporating these guidelines into their practice (Rushton et al., 2004). However, a staggering 26% of physicians in Rushton et al.’s study (2004) reported incorporating all of the AAP guidelines into their practice. In a similar university-based pediatric outpatient clinic, only 4% of pediatricians, pediatric residents, and nurse practitioners reported adhering to all four of the AAP 2007 guidelines when diagnosing childhood ADHD (Olson et al., 2005). An additional study found that while around 80% of pediatricians used formal diagnostic criteria in the assessment of ADHD, two-thirds reported using standardized rating scales, and about a quarter of pediatricians reported using DSM criteria to diagnose ADHD (Wolraich, Bard, Stein, Rushton, & O'Connor, 2010). According to Holmes and colleagues (2010), psychiatric settings diagnose children based on clinically elevated scores on hyperactive/impulsive and inattention domains on behavior checklists like the Conners Rating Scales (Conners, 1997) and ADHD-IV Rating Scale (DuPaul, Power, Anastopoulos, & Reid, 1998) that may or may not be combined with a semi-structured clinical interview and observation. Additionally, Faraone and colleagues (1995) found that clinicians often base their ADHD diagnoses on information that is provided solely by parent reports. Additional research suggests that only 38% of children with ADHD have any type of documentation that supports adherence to DSM-IV criteria (Epstein et al., 2008). Likewise, one in every three child psychologists report using a multi-method assessment approach that meets the standards of best practice (Handler & DuPaul, 2005).

Several factors contribute to poor adherence to current clinical guidelines including the amount of time necessary to conduct a thorough ADHD evaluation, the lack of proper training in the assessment and evaluation of childhood ADHD, and the lack of continued monitoring and education required to ensure that outpatient clinics, schools, and primary care settings are following evidence-based practice. Primary care physicians, in particular, report having an insufficient amount of time in a routine doctor's visit to conduct an assessment that adheres to AAP guidelines (Pritchard et al., 2012). In primary care pediatric settings, average patient visits tend to run from 12-20 minutes (Cox et al., 2007; Phillips et al., 1998; Rattay et al., 2004), leaving limited time to complete a diagnostic interview with parents and the patient and obtain additional information from multiple informants in other settings such as teachers or school support staff (Pritchard et al., 2012). Child psychologists working within a medical care setting also face similar constraints and prefer pragmatic assessment methods that are cost-effective, time-efficient, and easy to use; however, whether results lead to clear treatment implications remains open for debate (Blount, Bunke, & Zaff, 2000; Roberts & McNeal, 1995).

Conducting a comprehensive assessment is preferred over the use of single-informant reports because it provides clinicians with a more thorough understanding of the individual's difficulties and the opportunity to rule-out alternative explanations (Frazier et al., 2004). A thorough ADHD assessment is one that is reliable and valid, theory-driven, and evidence-based. It not only incorporates data on the behavioral manifestations of ADHD from multiple sources, but also includes measures of neuropsychological functioning using multiple assessment methods (Barkley, 1997; Barkley & Murphy, 2006; Hale et al., 2009; Reddy, Weissman, & Hale, in press). Because ADHD is conceptualized as a neurocognitive disorder with core deficits in neuropsychological and executive functioning, it is beneficial to outline the core components and benefits of utilizing a neuropsychological perspective in the assessment of children suspected of having an attentional disorder.

A comprehensive neuropsychological evaluation assesses multiple domains of functioning and incorporates informant data from multiple sources (e.g. self-report, caregivers, and teachers). A neuropsychological evaluation assesses an individual's neurobehavioral, cognitive, emotional, and social strengths and needs and also considers any co-occurring conditions (e.g., psychological, academic, cognitive, and medical). The primary goal of NP evaluations are to determine appropriate and targeted recommendations related to intervention and accommodations, both for the symptoms of ADHD itself and for co-occurring disorders, which span multiple domains. Lastly, it provides a psychometrically-defined baseline level of functioning to which treatment effects and developmental progress can be measured against (Pritchard et al., 2012).

Utilizing a neuropsychological perspective provides clinicians with a stronger foundation to integrate behavioral data resulting in a more unified and holistic picture of a child's functioning (Riccio & Reynolds, 1998). Also, adopting an integrated assessment approach has the potential to improve efficiency, diagnostic specificity, and treatment efficacy when working with ADHD children (Hale et al., 2009a). The combination of multiple sources of data from multiple informants offers an evidence-based approach that can pinpoint the unique and complex cognitive strengths and/or protective factors that may have the potential to moderate the impact of ADHD on a child's functioning at home and school (Hale et al., 2009). Lastly, the integration of evidence-based assessment and treatments for ADHD increases the likelihood that patients will receive the most comprehensive care that will in turn produce the best clinical outcomes (Lynch, Soon, & Chronis-Tuscano, 2010).

Research has also shown that neuropsychological testing plays an integral role in examining the effects of methylphenidate (MPH) on cognitive, academic functioning, and neuropsychological functioning. However, in the field of child psychiatry and psychology, the current standard of care for MPH titration includes the use of behavioral assessment methods, and rarely relies on direct neuropsychological testing or academic achievement data to determine treatment efficacy (Hale et al., 2011). Although research has shown that higher MPH doses effectively reduce noncompliant and disruptive behaviors in children with ADHD (Abikoff et al., 2004; Pearson et al., 2003; Van der Ooard, Prins, Oosterlaan, & Emmelkamp, 2008; Waxmonsky et al., 2008), few studies have examined the potentially detrimental effects on the executive control of attention (Konrad et al., 2004). In a recent study, Hale and colleagues (2011) investigated the cognitive and behavioral MPH effects on children behaviorally diagnosed with ADHD. Results confirmed that the best MPH dose for cognition might in fact be lower than the dose for behavior given the adverse effects of higher MPH doses on executive attention control and working memory functions. These results provide further evidence for the utility of incorporating neuropsychological measures in the assessment of MPH titration, and suggest that relying solely on behavioral titration measures alone leaves children with ADHD at risk for learning, memory, and achievement difficulties (Hale et al., 2011). Likewise, behavioral titration assessment methods alone are unlikely to lead to long-term treatment gains and academic and behavioral improvements (Jensen et al., 2007).

Although there are numerous benefits to utilizing a neuropsychological perspective in the assessment of childhood ADHD and conducting comprehensive evaluations, several drawbacks exists including the time-intensive nature of these evaluation and high costs associated with these evaluations. The cost of neuropsychological evaluations may range from $500 to $5,000 depending on the examiner's credentials, institution's reputation, and/or geographic location (Alderman, 2010). In addition, the cost may or may not be reimbursed by health insurance. It is also worth noting that not every child that presents with attentional problems may warrant a full neuropsychological test battery (Hale et al., 2009a). In these instances, researchers have argued for the use of brief executive and behavioral ADHD screeners that incorporate both indirect behavioral indicators of ADHD as well as direct neuropsychological performance measures thus reducing the need for costly and time-consuming comprehensive evaluations (Hale et al., 2009; Pedigo et al., 2009). However, additional research is needed to examine the clinical utility of assessment batteries used in the evaluation of ADHD to provide practicing psychologists with clinical information that can be used to make meaningful decisions regarding diagnostic accuracy, case formulation considerations, and treatment outcomes (Mash & Hunsley, 2005).

ADHD Assessment Domains

The ADHD assessment domains outlined in this paper are routinely used in comprehensive assessments conducted in school and primary care settings.

Cognitive Functioning. The evaluation of an individual's overall level of cognitive ability is a typical starting point when conducting a neuropsychological assessment (Frazier et al., 2004). Intellectual functioning is routinely assessed in school settings, outpatient clinics, and private practice settings, and results obtained from cognitive testing are frequently used in the determination of eligibility for special education and related services.

Cognitive testing allows practitioners to compare an individual child's test results in two ways: (a) against a set of developmental norms (normative analysis) (i.e. between the targeted child's performance and peers of the same age and sex, and (b) an ipsative analysis, which represent an individual's relative strengths and weaknesses on different indices of cognitive functioning (Calderon & Ruben, 2008).

Although intelligence tests like the Wechsler Intelligence Scale-4th edition (WISC-IV) are not designed to diagnose ADHD, some research has shown that measures of cognitive ability are sensitive to ADHD-specific impaired functioning (Frazier et al., 2004; Gibney, McIntosh, Dean, & Dunham, 2002). According to a meta-analysis of intellectual and neuropsychological test performance in ADHD, the Full Scale IQ of ADHD participants significantly differed from controls (Frazier et al., 2004). For most commercial IQ tests, the weighted mean effect size (d = .61) was roughly equivalent to a 9-point difference in FSIQ. The authors hypothesized that this difference may be attributed to "mild global cognitive inefficiencies or by multiple specific deficits affecting several cognitive abilities" (pp. 552, Frazier et al., 2004), and/or the possibility of test-taking differences between ADHD and control groups (Glutting, Youngstrom, Oakland, & Watkins, 1996).

Children with ADHD are also likely to earn their lowest index scores on either the Working Memory or Processing Speed indices on the WISC-IV (Mayes & Calhoun, 2007). Similarly, they also found that specific subtests on the Wechsler scales (i.e., Digit Span, Arithmetic, and Digit Symbol) that measure aspects of executive functions were effective in differentiating ADHD children from healthy controls. Children with ADHD have also demonstrated stronger performance on Digits Backwards than Digits Forward, often attributed to stronger motivation put forth given the additional manipulation to perform Digits Backwards (Oades & Christiansen, 2008). Although these subtests are also considered measures of working memory, they are discussed in this section given that they are routinely administered as part of a full cognitive assessment, and rarely used by themselves especially when assessing school-age children.

When the results of cognitive testing are combined with additional indicators of ADHD (i.e. clinical interviews, observations, and behavior rating scales), they can provide unique data on children’s information processing abilities that in turn inform intervention plans and academic recommendations (Calderon & Ruben, 2008).

Academic Functioning. Academic achievement in spelling, reading, and arithmetic are routinely used to assess the presence of a learning disability, a common comorbid condition with ADHD (Barkley, 1998; Dykman & Ackerman, 1991; Semrud-Clikeman et al., 1992). Likewise, when children are referred to the Child Study Team due to attentional difficulties coupled with academic skill deficits, it is paramount to determine whether the student’s academic underachievement is primarily due to ADHD, a learning disability, or both (DuPaul & Stoner, 2003).

Children with ADHD often have difficulty following directions, organizing and expressing their ideas orally and/or in writing, and lack consistency and accuracy when completing assigned tasks (Carlson, Lahey, & Neeper, 1986; Kim & Kaiser, 2000). These factors exert a strong negative influence on academic achievement in children with ADHD, and as a result, they struggle to produce grades that accurately represent their knowledge and abilities (DuPaul & Stoner, 2003). Measures of academic achievement, specifically spelling and arithmetic have been shown to be significantly more sensitive to children with ADHD than control groups (Frazier et al., 2004). Underachievement characteristic of ADHD populations, may also speak to the large impact executive functions have on academic performance. Therefore, measures of academic achievement may in fact be sensitive to the subtle weaknesses in neurocognitive abilities in addition to behavioral manifestation of ADHD that also inhibit learning (Slomka, 1998).

Given the adverse impact of inattentiveness and impulsivity on academic achievement, the assessment and monitoring of academic performance is crucial in the assessment of childhood ADHD.

Memory and Learning. One instrument that measures other aspects of memory and learning in children is the Wide Range Assessment of Memory and Learning-Second Edition (WRAML2; Sheslow & Adams, 2003). The WRAML2 was designed to assess memory abilities and differentiate between visual, verbal, or global memory deficits in children and adults (Maricle, Miller, & Mortimer, 2011).

Limited studies have examined the performance of children with ADHD on the WRAML-2. However, one study examined the performance of children with ADHD on measures of visuo-spatial working memory (i.e. Finger Windows subtest) and verbal working memory (i.e. Verbal Working Memory optional subtest) from the WRAML2 (Sowerby, Seal, & Tripp, 2011). Children with ADHD obtained significantly lower mean scores on these subtests than matched controls (Sowerby et al., 2011). Most studies have been conducted using the original WRAML (Sheslow & Adams, 1990), but research has been mixed on its ability to distinguish ADHD and Learning Disabled children from controls (Phelps, 1996). Research has shown that children with ADHD perform significantly worse on the WRAML's verbal list learning task than peers of the same age, gender, and grade level (Seidman et al., 1995). In a study of ADHD and Reading Disabled youth, results from the discriminant function analyses showed that the Verbal, Visual, Learning, and General Memory indices of the WRAML resulted in classification of only 49.5% of the children in the various groups (Dewey, Kaplan, Crawford, & Fisher, 1998). Children with ADHD have also been shown to perform poorly on the three WRAML subtests sensitive to attention and concentration (Kaplan, Dewey, Crawford, & Fisher, 1998). However, no studies to date exist on the WRAML2's ability to discriminate ADHD children from typically developing peers, and future studies are needed to address this gap.

Attention. Several tests of attention are routinely administered in ADHD evaluations. Attention involves several interrelated processes including arousal, orientation, concentration, perseverance, and vigilance (Mesulam, 1985; Denckla, 1989). Attention is also subject to fluctuations depending on several factors including motivation, self-esteem, anxiety, and mood (Baron, 2004). Several types or subdomains of attention exist; selective or focused attention, divided attention, sustained attention, and alternating attention/mental shifting attention (Baron, 2004). Selective attention refers to the ability to maintain a cognitive set while in the presence of background noise or distraction (Baron, 2004). Divided attention is defined as the ability to respond simultaneously to more than one task or event (Baron, 2004). The ability to maintain vigilance and consistently respond during continuous and repetitive activity describes sustained attention (Baron, 2004). Lastly, alternating attention refers is the ability to maintain mental flexibility in order to shift from one task to another when the tasks have different cognitive requirements. Several attention tests are briefly discussed below.

The Trail Making Test (TMT; Reitan & Wolfson, 1985) is one example of a selective attention task that is also sensitive to executive function subdomains of shift and sustain, and inhibitory control (Kelly, 2000). TMT-Part A is considered a test of attention, visuomotor speed, and tracking. Part B also assesses attentional control and directional scanning, and divided attention and additional executive function capabilities (Arbuthnott & Frank, 2000; Lamberty, Putnam et al., 1994). Part B has also been described as the more sensitive part of the Trail Making Test (Spreen & Strauss, 1998), with longer completion time indicating weaker ability in set shifting. Children with ADHD show impaired performance on Part B in comparison to healthy controls (Nigg, 2005).

Findings from a review examining differences between ADHD and non-disordered control subjects across four of six studies were promising because the observed effect size was large (d = .75) (Pennington & Ozonoff, 1996). Completion time on the TMT has also been shown to be longer in ADHD children in comparison to healthy controls, even when controlling for psychomotor slowness (Oades & Christiansen, 2008).

The majority of studies that examine sustained attention in children with ADHD utilize various versions of a continuous performance test (CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). Heaton and colleagues (2001) noted, “The most common CPT paradigms require subjects to sustain attention to various visual or auditory stimuli over an extended period of time and respond to certain target stimuli when they appear” (pp. 253). Generally, these tests range from 5-20 minutes in length. Several dependent measures result from these tests including the number of hits recorded, the mean reaction time to targets, the number of omission errors, and the number of incorrect responses to nontargets (i.e. commission errors). Omission errors reflect weaknesses in sustained attention or vigilance to the task, whereas commission errors reflect weaknesses in behavioral inhibition (Frazier et al., 2004).

Two of the most common CPTs in the assessment of attention in children are: the Test of Variables of Attention (TOVA; Greenberg & Kindschi, 1999) and the Conners' Continuous Performance Test-II (CPT-II; Conners & Multi-Health Systems [MHS] Staff, 2000). Past research has shown that children with ADHD commit more errors overall on CPT tasks in comparison to control subjects (Anderson, Holcomb, & Doyle, 1973; Corkum & Siegel, 1993; Douglas, 1983; Fischer, Barkley, Edelbrock, & Smallish, 1990; Hooks, Milich, & Lorch, 1994; Horn, Wagner, & Ialongo, 1989; O'Dougherty, Neuchterlein, & Drew, 1984; Seidel & Joshko, 1990). However, research has been mixed on the ability of these instruments to accurately discriminate between ADHD and control groups. For example, CPTs have been found to yield high positive predictive power (i.e. poor performance confirms the presence of ADHD-related symptoms) and relatively poor negative predictive power (i.e. passing performance yields inconclusive results) (Grodzinsky & Barkley, 1999; Reddy, Newman, Pedigo, & Scott, 2010). Although abnormal performance on a CPT may indicate a high likelihood of an ADHD diagnosis, children with ADHD are able to obtain non-elevated scores on the test, making the use of CPTs in isolation insufficient for diagnosing ADHD (Sims & Lonigan, 2012). Additionally, high rates of comorbidity and performance variability characteristic of an ADHD population also complicate CPT results (Hale, Fiorello, & Brown, 2005; Reddy & De Thomas, 2006). However, the use of CPTs as part of a comprehensive assessment battery reduces subjective biases implicit in behavior rating scales, and provides an objective assessment that affords clinicians with the opportunity to support or disconfirm subjective behavior ratings made by multiple informants (Sims & Lonigan, 2012).

Although research and theories of ADHD posit that executive function and attentional weaknesses are a core deficit in children with ADHD, practitioners are not likely to incorporate direct neuropsychological assessment measures when assessing for childhood ADHD, especially in school settings. For example, according to a recent survey of practicing school psychologists, over 87% of respondents reported that they would never use neuropsychological testing and continuous performance tests in the assessment of children suspected of having ADHD (Koonce, 2007).

Executive Functioning. Several neuropsychological tests that tap into subdomains of executive functions are routinely administered as part of a comprehensive ADHD evaluation. These include measures of planning, organization, reasoning, shift, inhibition, and fluency. Tests measuring one's ability to plan, organize, reason and shift include but are not limited to the Wisconsin Card Sorting Test (WCST; Heaton, 1981), and several tower tests including the Tower of London-Drexel University (Culbertson & Zillmer, 2000), the NEPSY Tower (Korkman, Kirk, & Kemp, 1998), and the Delis-Kaplan Executive Function System Tower Test (D-KEFS; Delis, Kaplan, & Kramer, 2001). Executive function tests that measure inhibition frequently include the Stroop Color-Word Test (Golden, 1978) or other versions and variations of the Stroop Procedure like the NEPSY-2 Auditory Attention and Response subtest (Korkman, Kirk, & Kemp, 2007) and D-KEFS Color Word Interference Test. Verbal fluency tasks are also included in several neuropsychological evaluations and test batteries including the NEPSY-2, D-

KEFS, and CELF-4. Several executive function subdomains are implicated in fluency tasks including working memory, self-monitoring, initiation, and shifting.

Embedded in the Pediatric Attention Disorders Diagnostic Screener (Pedigo, Pedigo & Scott, 2008), a multidimensional, computerized screening program designed to assess executive functioning and working memory, are three computer tests entitled the Target Tests of Executive Functions (TTEFs). Test developers posit that the TTEFs provide an objective assessment of a subject’s ability to employ various but not all executive processes: planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort (Pedigo et al., 2008). In their normative data, the TTEFs correctly classified the highest percentage of ADHD children at 94%, followed by the Conner’s CPT-II at 68% and the Brown ADD Scales at 66%.

One indirect measure of executive functioning is the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000), a behavior rating scale designed to measure several domains of executive functioning including inhibition, shift, emotional control, initiation, working memory, planning/organization, organization of materials, and self-monitoring. Several studies support the BRIEF’s ability to discriminate ADHD children from normal controls (Gioia & Isquith, 2002; Mahone et al., 2002; Mares et al., 2007; McCandless & O’Laughlin, 2007; Reddy, Hale, & Brodzinsky, 2011).

Given the significant impact of executive function deficits on academic and psychosocial functioning across environments (Biederman et al., 2004), combining direct neuropsychological testing with indirect parent and teacher behavior ratings that assess various subdomains of executive functions may prove useful when conducting ADHD evaluations (Hale et al., 2009).

Behavioral Functioning. Behavior rating scales are one of the most commonly used measures for extrapolating information from multiple sources of data in the evaluation of ADHD (Calderon & Ruben, 2008). The use of behavior rating scales is advantageous because they allow clinicians to obtain data from multiple informants who are familiar with the child and observe the child's behavior in a number of settings, (b) allow for the collection of information on specific and global behaviors that are unlikely to be seen through direct observation, (c) offer an efficient, flexible, cost-effective method of data collection, and (d) allow for a child's score to be compared against normative data based on age and gender (Barkley, 1990; Smith & Reddy, 2002). Some rating scales are also standardized, psychometrically sound, and sensitive to treatment effects (Pelham et al., 2005).

Despite these benefits, drawbacks exist when behavior rating scales are used as the primary source of clinical information. Given the co-occurrence of ADHD and learning, mood, and anxiety disorders, relying solely on rating scales presents with numerous limitations (Pritchard et al., 2012) including poor interrater reliability between parents and teachers, which is likely attributed to different demands of the home and school setting (Murray et al., 2007). Research has consistently shown that behavior rating scales alone exhibit limited ability to discriminate between ADHD and other disorders, as well as among ADHD subtypes (e.g., Hale, How, Dewitt, & Couy, 2001, Mahone et al., 2002, Sullivan & Riccio, 2007). Rating scales are not sensitive to changes following treatment (Foster & Mash, 1999; Pelham & Fabiano, 2008) and demonstrate limited treatment utility and predictive validity (Pelham et al., 2005). It is expected that behavior ratings obtained from multiple sources may vary in degree and severity (Fisher, Barkley, Fletcher, & Smallfish, 1995; O'Donnell et al., 1998), and that the level of agreement of behavioral ratings across settings will be low (e.g., Antrop, Roeyers, Oosterlaan, & Van Oost, 2002; Gomez, Burns, Walsh, & de Moura, 2003; Gomez, Burns, Walsh, & Hafetz, 2005; Mares et al., 2007), however, collecting data from multiple informants can assist in overcoming biased reporting (Crystal et al., 2001). Similarly, behavioral criteria alone may be insufficient given the variability in ADHD symptoms across environments (Wolraich et al., 2004) and the possibility of multiple underlying causes for the behavior (Reddy & Hale, 2007).

Although rating scales are an efficient means of collecting behavioral data from multiple sources; when used alone, they provide little information regarding the child's cognitive and academic strengths and areas of need.

Comorbidity/Differential Diagnosis. A comprehensive ADHD assessment must also assess the presence of comorbid disorders in order to rule-out another disorder that may mimic the same clinical presentation and symptoms of ADHD (Preston, Fennell, & Bussing, 2005). For example, symptoms commonly observed in children with ADHD (i.e. difficulty concentrating, motor restlessness, and racing thoughts) are common in other emotional and behavioral disorders like learning disorders, anxiety, and depression (APA, 2000). Similarly, sleep disorders, pervasive developmental disorders, and medical conditions such as thyroid disease are often characterized by inattention, social skill deficits, and hyperactive and/or idiosyncratic behaviors (Adler, Barkley, Wilens, &

Ginsberg, 2006). ADHD also overlaps considerably with Obsessive Compulsive Disorder and Tourette's syndrome (Grados et al., 2008).

In community samples, up to 44% of children with ADHD have at least one other disorder and 43% have at least two or more additional disorders (Szatmari et al., 1989). In children drawn from clinic samples, as much as 87% of clinically diagnosed ADHD children may have at least one other disorder and 67% have at least two other disorders (Kadesjo & Gillberg, 2001). Disorders that are commonly comorbid with ADHD such as Learning Disabilities, Oppositional Defiant Disorder, Conduct Disorder, Anxiety and Depression, all share symptoms that may mimic ADHD symptomatology (Adler et al., 2006; Barkley, 1996, 1998; Hale & Reddy, 2007). Data from the National Comorbidity Study Replication indicated that 32% of ADHD patients meet criteria for unipolar depression, 21% meet criteria for bipolar disorder, and 9.5% meet criteria for anxiety disorders (Adler, Sitt, Nierenberg, & Mandler, 2006).

Given these high rates of comorbidity in children with ADHD and common symptom overlap between ADHD and other related disorders and/or medical conditions, multi-domain assessments across contexts are essential for the diagnostic process (Dietz & Montague, 2006; Pineda et al., 2007). Additionally, improper and ineffective diagnosis leads to ineffective treatment and intervention planning (Pritchard, Nigro, Jacobsen, & Mahone, 2012).

Purpose

The present investigation assessed the differences between ADHD and Non-ADHD youth on direct and indirect measures used in the assessment of childhood ADHD. Specifically, the study addressed two questions:

Question 1: Do private practice-referred elementary-aged children with ADHD perform differently on direct measures of neuropsychological functioning than youth without ADHD?

Question 2: Do private practice-referred elementary-aged children with ADHD perform differently on indirect measures of behavior functioning than youth without ADHD?

Hypotheses

Hypothesis 1: Elementary-aged children with ADHD will yield statistically significant mean score differences on direct measures of neuropsychological functioning [i.e., The Pediatric Attention Disorder Diagnostic Screener Target Tests of Executive Functioning (PADDS TTEFs; Pedigo, Pedigo, & Scott, 2008), the Wide Range Assessment of Memory and Learning-Second Edition (WRAML-2; Sheslow & Adams, 2003), and the Trail Making Test-Parts A/B (Reitan & Wolfson, 1985)] than children without ADHD as measured by univariate tests. Specifically, the ADHD sample will yield lower mean scores on each of these measures in comparison to the Non-ADHD sample.

Hypothesis 2: Elementary-aged with ADHD will yield practically significant differences on direct measures of neuropsychological functioning than youth without ADHD as measured by *d*-ratios. Specifically, the ADHD sample will yield larger effect sizes on direct measures of neuropsychological functioning than youth in the Non-ADHD sample.

Hypothesis 3: Elementary-aged children with ADHD will yield statistically significant mean score differences on indirect measures of behavior (i.e., Behavior Rating Inventory of Executive Function, Parent and Teacher Forms (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2005) compared to youth without ADHD. Specifically, the ADHD sample will yield higher mean scores on each of the scales on the BRIEF Parent and Teacher Forms than youth in the Non-ADHD sample.

Hypothesis 4: Elementary-aged children with ADHD will yield practically significant mean score differences on indirect measures of behavior compared to youth without ADHD. Specifically, the ADHD sample will yield larger effect sizes on each of the scales on the BRIEF Parent and Teacher scales than youth in the Non-ADHD sample.

CHAPTER III

Method

Sample

The total sample consisted of 80 children referred to a private practice ranging in age from 6 to 12 years old, with a mean age of 9.45 years (*SD* = 1.49 months). The ADHD (*n* = 40) and Non-ADHD sample (*n* = 40) were matched on age. The Non-ADHD sample of children were matched based on the age from the ADHD sample, and an exact age match was obtained for each Non-ADHD child. Children in the Non-ADHD sample were randomly selected from a pool of 300 evaluations conducted over a 15-month period. Children in the Non-ADHD sample did not hold a diagnosis of ADHD. Sixty-six percent of the total sample was male (*n* = 53) and 34% was female (*n* = 27). Sixty-one percent of the sample was Caucasian, 29% African American, and 2% Hispanic. Participants were not on any medication to treat ADHD at the time of evaluation. Participants were administered the Reynolds Intellectual Assessment Scales (RIAS; Reynolds & Kamphaus, 2003) to assess cognitive functioning as part of the evaluation. No statistically or practically meaningful (*d*-ratios) differences between groups were present on each of the RIAS Indices (See Table 1).

The ADHD sample was 73% male (*n* = 29) and 27% female (*n* = 11), with a mean age of 9.16 (*SD* = 1.48). Fifty-seven percent of the ADHD group was Caucasian, 37% African American, and 5% Hispanic. Fifty-seven percent of the ADHD sample held a diagnosis of Combined Type (*n* = 23), 40% Predominately Inattentive Type (*n* = 16), and 2% Hyperactive/Impulsive Type (*n* = 1).

The Non-ADHD sample was 60% male (*n* = 24) and 40% female (*n* = 16), with a mean age of 9.75 (*SD* = 1.46). Sixty-five percent of the Non-ADHD sample was Caucasian and 35% African American. The comparison sample included youth diagnosed with Adjustment Disorder (*n* = 15), Specific Learning Disability (*n* = 12), no psychiatric diagnosis (*n* = 8), Anxiety Disorder NOS (*n* = 1), Generalized Anxiety Disorder (*n* = 1), Mixed Receptive-Expressive Language Disorder (*n = 1)*, Oppositional Defiant Disorder (*n* = 1), and Hypothyroidism (*n* = 1).

Procedure

The sample was drawn from the private practice in the Southern United States of one of the test developers of the Pediatric Attention Disorders Diagnostic Screener (PADDS, Pedigo, & Scott, 2008). Children presented to the private practice to obtain a private comprehensive psychological evaluation by a licensed psychologist. Children were referred to the private practice due to a variety of concerns including attentional, academic/learning, and/or social/emotional functioning. Based on the data collection source, this was considered the first comprehensive psychological evaluation undergone by the participants. All test data obtained from the evaluation were used in the diagnostic decision-making process.

Written informed consent was obtained from all parents/legal guardians. Only de-identified data was used for this study. Data were collected by the private practice between July 2010 and July 2011. Institutional Review Board approval was obtained through Rutgers University's Office of Research and Sponsored Programs in February 2012 to obtain and use the data set for research purposes.

Measures

Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2005). The BRIEF parent and teacher rating scales measure eight clinical subscales of ADHD-related executive functioning impairment (e.g., Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor). The eight clinical subscales form two broad indices Behavioral Regulation and Metacognition as well as a Global Executive Composite. The BRIEF scales have shown high levels of internal consistency with Cronbach's alpha ranging from .80 to .90 across the subscales of the teacher and parent version of the BRIEF (Gioia et al., 2005). The BRIEF scales have also shown good stability with an average test-retest reliability of .81, ranging from .76 to.85 over a two-week period for the parent form and an average test-retest reliability of .87 (range = .83 to .92) over an average of 3.5 weeks for the teacher form.

The Pediatric Attention Disorder Diagnostic Screener Target Tests of Executive Functioning (PADDS TTEFs; Pedigo, Pedigo, & Scott, 2008). The Pediatric Attention Disorders Diagnostic Screener is a computerized attention and executive function screening system that is comprised of three components: a Computer Administered/Scored Diagnostic Interview (CADI), the SNAP-IV (Swanson, Nolan, & Pelham, 1992), a standardized rating scale of diagnostic criteria for each subtype of ADHD, and the Target Tests of Executive Functioning (TTEFs), three computer-based tasks that measure executive functions. In the current study, only data from the TTEFs were used. The TTEFs are comprised of three short and engaging computer tasks entitled: Target Recognition, Target Sequencing, and Target Tracking. *Target Recognition* requires participants to select the correct number of targets they see with a smaller square inside a larger square of the same color for a total of 153 presentations. *Target Sequencing* requires participants to attend to a sequence of small squares of varying colors passing through larger circles of varying colors, and then click, in the corresponding order, on only the circles that contained squares of the same color across 39 trials. Lastly, *Target Tracking* requires the participant to attend to moving targets, track the order, and then move the targets in the same order across 20 trials. TTEF scores are calculated based on the number of correct hits, and compared against the mean scores of same-aged, typically developing peers from the standardization sample.

As previously noted, these tasks do not attempt to isolate specific executive functions. However, they do increase in difficulty, as the second task requires the respondent to remember the sequence of presentations, and the third task requires the respondent to copy the presentation sequence, thereby adding an expressive/motor component. The TTEFs have strong reliability and validity, and have demonstrated good test-retest (for one year intervals) reliability, Phi of .73 and Kappa of .70, and a stability coefficient of .85. A comparison of agreement of diagnostic classification of the TTEFs and the Brown scales and the TTEFs and the CPT-II produced agreement percentages of 66% and 63%, respectively.

Trail Making Test-Part A/B (TMT-Part A/B; Reitan & Wolfson, 1985). The TMT is part of the Halstead-Reitan Neuropsychological Test Battery and assesses the ability to shift attention between mental sets, and has been shown to be a direct measure of executive functioning (Arbuthnott & Frank, 2000). TMT-Part A requires participants to draw a pencil line from one encircled symbol to the next in ascending order without lifting the pencil from the paper. The TMT-Part B also requires participants to draw pencil lines from one encircled symbol to the next, but mentally shifting back and forth between numbers and letters in ascending order. Scores are based on completion time. Subjects age 8 and up were administered Part A and B of the TMT.

Wide Range Assessment of Memory and Learning-Second Edition (WRAML2; Sheslow & Adams, 2003). The WRAML2 is a neuropsychological test of memory functions that can be used across the lifespan. The core battery of the WRAML-2 is comprised of verbal memory, visual memory, and attention and concentration indices, which combine to yield a General Memory Index. Supplementary indices measure working memory, delayed memory, and recognition. Coefficient alpha reliabilities for the Core Battery Verbal Memory Index, Visual Memory Index, and Attention-Concentration Index are .92, .89, and .86 respectively (Shelsow & Wayne, 2003). Coefficient alpha for the General Index is .93.

Data Analyses

Three analytic methods were used. First, descriptive statistics were computed for both groups on all measures. Second, two-sample t-tests (with Bonferonni correction) were computed to assess statistically significant mean differences between groups. Third, *d*-ratios were computed to assess the effect size and help evaluate the practical (clinically meaningful) differences between groups. D values of .2 are considered small, .5 medium, and .8 large (Cohen, 1988). Two correlational analyses were also conducted to examine the relationship between all direct measures of neuropsychological functioning in the ADHD group and in the Non-ADHD group.

CHAPTER IV

Results

As shown in Table 2, descriptive statistics, two-sample t-tests, and effect sizes (d values) were computed between the ADHD and Non-ADHD samples for all direct neuropsychological assessment measures. Data was examined for violations of normality and homogeneity of variance. Levene's Test of Homogeneity of Variance was statistically significant on four measures: TTEFS Target Recognition, Target Sequencing, and Target Tracking; and WRAML-2 Attention and Concentration Index. Therefore, the alternate t statistic and the degrees of freedom for ‘‘equal variances not assumed’’ were used for tests of these measures.

Results revealed significant group differences on the TTEFs, three WRAML2 indices, and TMT-Part B. Significant differences were found on each of the TTEFs: Target Recognition $t(74.816) = 5.04$, $p < .001$, Target Sequencing $t(65.666) = 6.95$, $p < .001$, and Target Tracking $t(69.592) = 6.24$, $p < .001$. In each case the ADHD group performed worse. Large effect sizes were found on the TTEFs (1.12 to 1.55). Significant differences were also found on three of four WRAML-2 indices: Visual Memory $t(78) = 3.34$, $p < .001$), Attention and Concentration $t(70.732) = 3.92$, $p < .001$, and General Memory $t(78) = 4.71$, $p < .001$. Again, the ADHD group evidenced poorer performance than the comparison group. Large to medium effect sizes were also found on these measures (Cohen, 1988). Lastly, a statistically significant difference between groups was found on Trail Making Test-Part B $t(66) = 3.42$, $p < .001$, with the ADHD group scoring lower than the comparison group. A large effect size was found for TMT-Part B (-.83). See Table 2.

As for the indirect neuropsychological assessment measures, non-significant differences were found between groups on the BRIEF Parent and Teacher Forms (see Table 3).

Correlations were computed among all direct neuropsychological functioning measures within the ADHD group (n = 40) and within the Non-ADHD group (n = 40). For the ADHD group, results suggest that the correlation between Target Recognition and Target Sequencing was statistically significant $r(38) = +.41$, $p < .01$, two-tailed (see Table 4). The WRAML2 General Memory Index was also significantly correlated with each WRAML2 index, with correlations greater than or equal to $r(38) = +.54$, $p < .01$, two-tailed. For the Non-ADHD group, all of the TTEFS were significantly correlated with one another and were greater than or equal to $r(38) = +.47$, $p < .01$, two-tailed (see Table 5). The WRAML2 General Memory Index was significantly correlated with the Verbal Memory and Visual Memory Indices ($p < .01$). The Verbal Memory Index was also significantly correlated with the Visual Memory Index for the Non-ADHD group $r(38) = +.50$, $p < .01$, two-tailed.

CHAPTER V

Discussion

The present study examined the clinical utility of direct measures of neuropsychological functioning and indirect behavior rating among an age-matched sample of ADHD and non-ADHD children. It was hypothesized that ADHD children would yield lower scales scores on direct neuropsychological measures. Consistent with our hypothesis, youth in the ADHD group performed significantly worse on direct neuropsychological measures and yielded significantly lower mean scores on each of the TTEFs, WRAML-2 indices, and TMT-Part B than youth in the Non-ADHD group. Large effect sizes (Cohen, 1988) were found on the three TTEFs, WRAML-2 Attention/Concentration and General Memory Indices, and TMT- Part B. A medium effect size was found on the WRAML2 Visual Memory Index.

It was also hypothesized that ADHD youth would yield more elevated *T*-scores on parent and teacher behavior rating scales in comparison to non-ADHD youth, however, no significant mean score differences were found on the BRIEF-Parent and Teacher Forms. Effect sizes may be practically meaningful (i.e., small to medium ESs) for the BRIEF-Teacher Form, but the power to detect smaller effect sizes was not adequate in the current study. For example, power to detect a medium-sized difference (d = .5) was 35% using an alpha of .01, according to Cohen, 1988. Mean scores were similar across all BRIEF-Parent Form scales for both groups, suggesting that characteristics of ADHD and executive dysfunction, as measured by the BRIEF Form, may not only be specific to children with ADHD (Sullivan & Riccio, 2007). Likewise, executive dysfunction may be implicated in multiple psychiatric disorders other than just ADHD (Anderson et al., 2002;

Gioia et al., 2002; Shear et al., 2002). In one study, Sullivan and Riccio (2007) examined diagnostic group differences in parent and teacher ratings on the BRIEF and Conners' scales, and found that ADHD and other clinical groups received similar scores on these scales, supporting our assertion that these scales may be less successful at discriminating children with ADHD from those with other clinical diagnoses. More specifically, the BRIEF-Parent Form may not be as sensitive in discriminating ADHD youth from youth with other clinical disorders.

Limited studies have analyzed differences between ADHD youth and non-ADHD groups on behavior rating scales. Nonetheless, results are consistent with previous studies' examination of the differences between parent and teacher ratings on the BRIEF. For example, consistent with this study, teacher ratings of the ADHD youth were more elevated on all BRIEF scales relative to the Non-ADHD group in comparison to parent ratings (Gioia et al., 2000; Mares et al., 2007).

In contrast with several studies (Mahone et al., 2002; McCandless & O'Laughlin, 2007), ADHD youth did not show significantly more impairment on the Working Memory scale for both the BRIEF-Parent and Teacher Form, however this is inconclusive due to the low power. The lack of significance is consistent with the role of the deficits in working memory and executive functions in other clinical disorders. However, the present investigation did not use a true control group, further suggesting that the BRIEF Working Memory scale for both Parent and Teacher Forms may not be as sensitive in discriminating between ADHD and Non-ADHD children.

To date, no independent studies have examined the score differences of ADHD youth in comparison to non-ADHD youth on the WRAML-2 indices. Although this study did not perform discriminant function analyses, ADHD youth performed significantly worse on WRAML-2 measures of general memory, visual memory, and attention and concentration than non-ADHD counterparts, further illustrating more significant deficits in memory functioning in ADHD children. These results also support the assessment of memory functions in ADHD populations.

Hale, Reddy and colleagues (2009) examined the utility of indirect teacher behavior ratings and direct neuropsychological assessment for differentiating ADHD, specific learning disability, and typical child samples (Hale et al., 2009). Results (i.e., Wilks's Λ and Cohen's *d* values) suggested that indirect behavior ratings were more effective than neuropsychological measures in discriminating typical and ADHD groups. Although the current study did not perform discriminant function analyses, results suggest that the opposite would be true given the robust effect sizes found on all of the direct neuropsychological measures analyzed in our study versus the absence of differences for indirect behavior ratings.

Implications for Practice

Results gleaned from this study illustrate the importance of incorporating both direct measures of neuropsychological functioning and indirect behavior rating scales when conducting a comprehensive ADHD assessment. Rating scales do not replace the need for direct performance measures given that they are susceptible to bias, may have low inter-rater agreement, and insensitivity in discriminating between ADHD and Non-ADHD peers. Rating scales alone do not aid in differential diagnosis and only provide a limited amount of information that is not likely to inform case formulation and academic recommendations. However, when indirect and direct assessment measures are combined, clinicians obtain a greater breadth of clinical information that can be used to monitor medication status, determine neurocognitive strengths and weaknesses, and develop appropriate interventions and recommendations. Assessments that are grounded in theory with strong psychometric properties provide clinicians with an evidence-based and empirically supported framework to operate within, which in turn has the power to inform treatment and medication options.

Limitations

The present study includes limitations. First, the sample was not large enough to detect moderate effect sizes between groups, making it difficult to interpret non-significant differences on indirect behavior rating scales (see Fagley, 1985). Second, the samples were matched on age, but not on race, gender, or socioeconomic status thus somewhat limiting the study's generalizability. However, this sample is similar to that of other studies previously cited (e.g. Mahone et al., 2002; McCandless & O'Laughlin, 2007). Third, the current study did not include direct observation data, which can provide important clinical information. Lastly, although the current evaluation conducted by the examiner was considered each child's first lifetime comprehensive psychological assessment, this did not preclude a parent from obtaining clinical impressions and/or consultation from a pediatrician, neurologist, and/or psychologist.

Another potential limitation of the study to consider is that the clinicians conducting the evaluation may have also heavily relied on the direct neuropsychological test results to make an ADHD diagnosis. If the diagnosis of ADHD was based primarily on the direct neuropsychological test results, then it is likely that these scores significantly differentiated between those diagnosed with ADHD and those with other or no diagnoses. Certainly, all clinicians are susceptible to their own set of biases when approaching a case, but being aware of the benefits of utilizing an evidence-based perspective as well as the limitations of using indirect or direct evaluation methods in isolation can prove clinically useful.

Directions for Research

Future research studies should include a broader sampling of diagnosticians from multiple sites in order represent a more heterogeneous diagnostic source of clinical data. Also, the inclusion of direct observation provides examiners with additional data that strengthens and informs diagnostic decision making.

Additional research with larger and heterogeneous clinical samples is needed to analyze the sensitivity and specificity of instruments used in the diagnosis of childhood ADHD. Likewise, future studies are needed to examine the clinical utility of omnibus and disorder-specific behavior rating scales, especially with ADHD and psychiatric populations that present with similar symptomatology like Anxiety, PTSD, and Adjustment Disorder. Future research can also examine ADHD subtype differences, especially Combined Type versus Inattentive Type, on neuropsychological measures as well as behavior rating scales. Lastly, future research should also examine the incremental validity of direct and indirect assessment tools for diagnosing children suspected of having an attentional disorder.

Conclusion

A multi-source, multi-method evaluation approach for children at risk for ADHD affords clinicians the opportunity to tap into the heterogeneous and neuropsychologically complex nature of ADHD that cannot be fully assessed with indirect behavioral measures alone. The combination of direct neuropsychological assessment measures with behavioral assessment methods aides in differential diagnosis and informs case formulation, treatment planning and intervention, and is consistent with the tenets of evidence-based assessment (Mash & Hunsley, 2005).

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Table 1

Group Comparison of Mean Scores and Standard Deviations: Reynolds Intellectual Ability Scale Scores

	ADHD (n = 40)		Non-ADHD (n = 40)			
Measure	*M*	*SD*	*M*	*SD*	*t*	*d*[a]
RIAS						
Composite IQ	98.23	9.39	101.45	12.7	1.29	.28
Verbal IQ	95.68	9.73	99.55	13.91	1.44	.32
Nonverbal IQ	102.38	10.6	104.33	11.65	.78	.17
Memory Composite	97.35	8.16	101.6	11.78	1.87	.41

Note. RIAS = Reynolds Intellectual Assessment Scale (Reynolds & Kamphaus, 2003).
[a] Effect sizes: .2 small, .5 medium, and .8 large (Cohen, 1988).

Table 2

Group Comparison of Mean Scores and Standard Deviations for Direct Neuropsychological Assessment Measures

	ADHD (n = 40)		Non-ADHD (n = 40)			
Measure	*M*	*SD*	*M*	*SD*	*t*	*d*
TTEFs[1]						
Target Recognition	98.25	27.09	126.08	21.97	5.04*	-1.13
Target Sequencing	22.68	7.33	32.2	4.61	6.95*	-1.55
Target Tracking	7.43	2.67	12.05	3.84	6.24*	-1.39
WRAML2 Indices						
Verbal Memory	90.45	11.39	98.45	10.80	3.22	-.72
Visual Memory	86.38	17	97.83	13.45	3.34*	-.75
Attn/Concentration	85.63	12.49	95.15	8.96	3.92*	-.87
General Memory	83.68	12.10	95.75	10.52	4.76*	-1.06
	ADHD (n = 33)		Non-ADHD (n = 35)			
TMT[2]						
Part A	81.36	20.86	90.80	17.05	2.05	-.49
Part B	75.91	16.65	89.29	15.51	3.43*	-.83

Note. * $p < .001$. TTEFs = Target Tests of Executive Functioning (Pedigo, Pedigo, & Scott, 2008). WRAML2 = Wide Range Assessment of Memory and Learning- 2nd Edition (Sheslow & Adams, 2003). TMT = Trail Making Test (Reitan & Wolfson, 1985)
[1] Means are based on raw scores; higher scores indicate better performance. [2] Normed for ages 8 and up.

Table 3

Group Comparison of Mean Scores and Standard Deviations for the BRIEF Parent and Teacher Form Scales

	ADHD (n = 40)		NONADHD (n = 40)			
Measure	*M*	*SD*	*M*	*SD*	*t*	*d*
BRIEF Parent						
Inhibition	62.83	12.89	58.70	13.49	-1.39	.31
Shift	60.70	12.54	56.05	12.88	-1.63	.36
Emotion	56.93	13.10	54.23	11.86	-.96	.21
BRI	61.03	13.58	58.18	12.85	-.96	.10
Initiate	59	10.36	63.35	11.23	1.8	-.40
Working Memory	66.85	10.99	68.05	9.90	.51	-.11
Plan	64.08	10.57	67	10.13	1.2	-.28
Organize	59.63	9.17	59.83	8.33	.1	-.02
Monitor	60.9	11.69	63.15	9.32	.95	-.21
MI	63.93	10.75	65.73	9.65	.78	-.17
GEC	63.1	10.55	64.35	10.42	.53	-.12
BRIEF Teacher						
Inhibition	68.70	16.10	58.55	13.20	-3.08	.68
Shift	63.58	17.92	56.88	10.62	-2.03	.45
Emotion	65.55	18.32	55.75	11.27	-2.88	.64
BRI	68.08	17.15	57.8	12.34	-3.07	.68
Initiate	68.68	12.82	62.5	13.52	-2.09	.46
Working Memory	74.75	15.17	69.03	13.54	-1.78	.39
Plan	69.48	12.41	62.28	12.88	-2.54	.56
Organize	63.38	19.58	59.30	13.04	-2.43	.54
Monitor	69.43	14.59	62.50	12.22	-2.30	.51
MI	72	14.52	64	10.87	-2.78	.62
GEC	71.78	15.39	63.6	11.45	-2.69	.60

Note. BRIEF = Behavior Rating Inventory of Executive Function (Gioia, Isquith, Guy, & Kenworthy, 2000). BRI = Behavior Regulation Index; MI = Metacognition Index; GEC = Global Executive Composite.

Table 4

Correlation of Direct Neuropsychological Functioning Measures: ADHD Group

Measures	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	
1. Target Rec	-								
2. Target Seq	.416**	-							
3. Target Trac	.054	.341*	-						
4. WRAML2 VMI	-.152	-.009	-.200	-					
5. WRAML2 ViMI	-.011	.283	.014	.388*	-				
6. WRAML2 A/CI	.048	-.103	-.146	.134	.197	-			
7. WRAML2 GMI	-.026	.143	-.117	.679**	.823**	.543**	-		
8. TMT-A	-.158	.185	.271	.051	.330	.104	.272	-	
9. TMT-B	.210	.229	.153	-.002	.351*	-.183	.199	.431*	-

Note. * p < .05, two-tailed. ***p* < 0.01, two-tailed.

Table 5

Correlation of Direct Neuropsychological Functioning Measures: Non-ADHD Comparison Group

Measures	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	
1. Target Rec	-								
2. Target Seq	.471**	-							
3. Target Trac	.546**	.562**	-						
4. WRAML2 VMI	.211	.019	.184	-					
5. WRAML2 ViMI	.213	.120	.125	.502**	-				
6. WRAML2 A/CI	-.104	-.121	-.027	.052	.010	-			
7. WRAML2 GMI	.186	.031	.153	.790**	.823**	.390*	-		
8. TMT-A	.260	.225	.033	.160	.257	-.017	.226	-	
9. TMT-B	.282	.201	.229	.351*	.372*	-.080	.356*	.307	-

Note. * $p < .05$, two-tailed. ** $p < 0.01$, two-tailed.

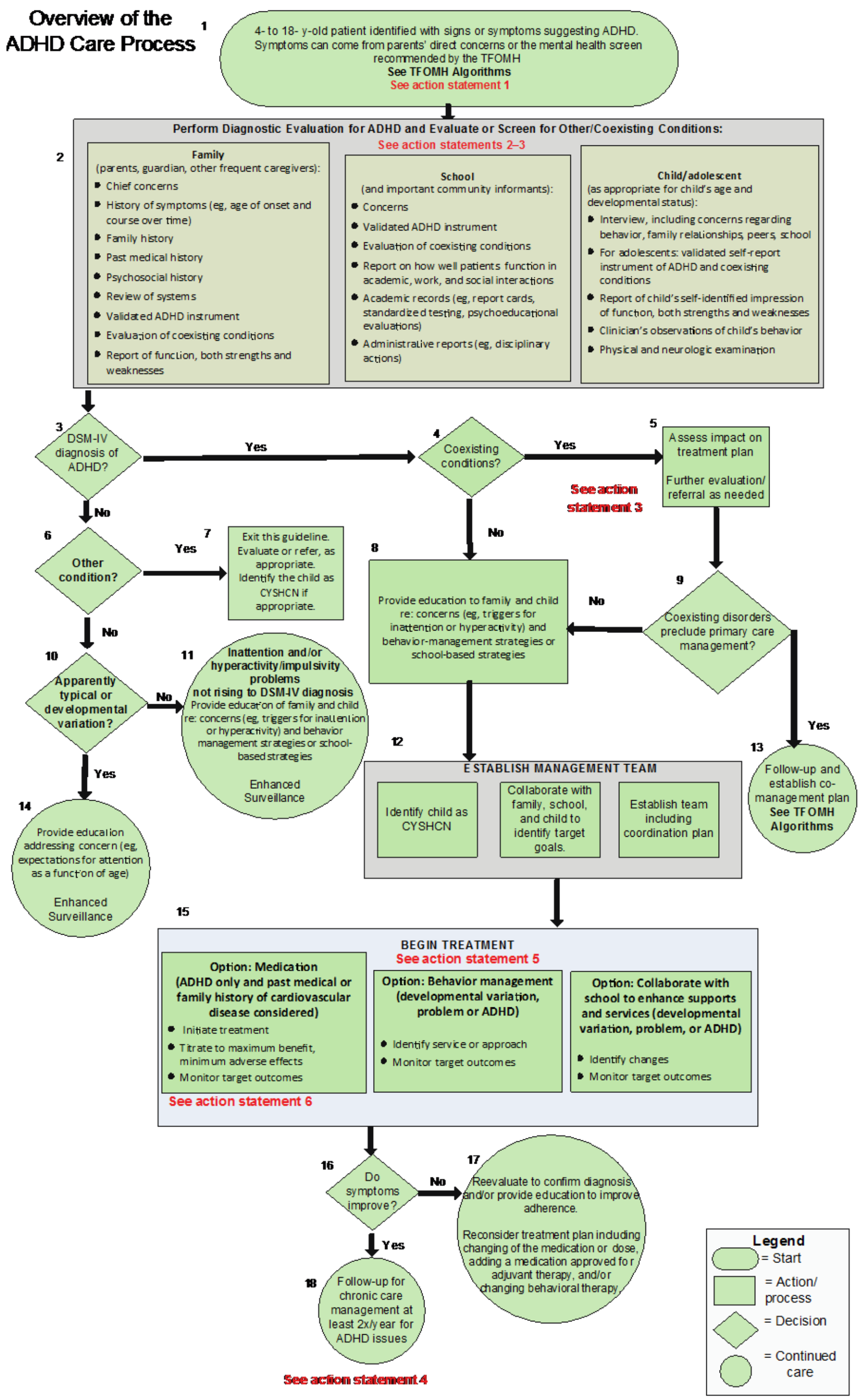

Figure 1. Adapted from American Academy of Pediatrics (2000). Clinical practice guideline: Diagnosis and evaluation of the child with attention-deficit/hyperactivity disorder. *Pediatrics, 105,* 1158-1170.