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REVIEW

The Role of Neuropsychological Assessment in the Functional Outcomes of Children with ADHD

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Abstract The value of evidence-based services is now recognized both within clinical communities and by the public at large. Increasingly, neuropsychologists must justify the necessity of often costly and time-consuming neuropsychological assessments in the diagnosis and treatment of common childhood disorders, such as Attention-deficit/Hyperactivity Disorder (ADHD). Published medical guidelines and prominent researchers, however, have argued against the need for formal neuropsychological assessment of ADHD. The present review examines the literature on developmental outcomes in childhood ADHD, with emphasis on the utility of formal neuropsychological assessment among children diagnosed and treated in primary care settings. The review yields three central findings: 1) adherence to published diagnostic guidelines for ADHD is poor among pediatric and primary care physicians; 2) ADHD most often co-exists with other disorders, thus diagnoses made without formal psychometric assessment can be incomplete or incorrect, ultimately increasing treatment costs; and, 3) untreated children with ADHD, and those who have untreated comorbidities, are at greater risk for poor outcomes in social, academic, vocational, and practical settings. The available literature suggests that neuropsychological assessment provides information that can potentially reduce risks for poor outcomes and improve quality of life among children with ADHD. Controlled studies directly examining the impact of neuropsychological assessments in improving outcomes among children with ADHD are needed.

Keywords Evidence-based practice · Outcomes · Neuropsychological · Psychometric assessment · Childhood · Quality of life

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Neuropsychological Assessment in the Management of Childhood ADHD

Increasingly, clinical services must be justified by scientific evidence that speaks to their effectiveness in order to be considered as reasonable options for treatment. The value and necessity of evidence-based services has become widely recognized within clinical communities ranging from psychologists to physicians and beyond (American Academy of Pediatrics 2000; American Psychological Association 2002). In addition, third party payors rely heavily on evidence for treatment effectiveness in their decision-making processes (Levant and Hasan 2008). While research on the etiology, sequelae, comorbidities, and treatment of Attention-deficit/Hyperactivity Disorder (ADHD) abound, virtually no studies have been published to address the following question: *To what extent does neuropsychological assessment have value in guiding treatment, contributing to accuracy of diagnoses, reducing symptoms, and improving quality of life among children with ADHD and their families?* The dearth of effectiveness data on neuropsychological assessment in ADHD, in combination with arguments made in public forums and

by influential researchers against the necessity for such evaluations (e.g., Alderman 2011), have raised questions about their utility as an empirically-supported treatment. This issue is essentially one of incremental validity. That is, do neuropsychological assessments contribute to improved accuracy in diagnosis and/or to better outcomes than diagnoses made on the basis of clinical observations, rating scales, and/or unstructured interviews alone? In the interest of clarity, we define the *neuropsychological* assessment of a child as an evaluation by a trained neuropsychologist (Barth et al. 2003; Hannay et al. 1998) of the following skills, as appropriate to the case at hand: general intelligence, academic achievement, executive functions, attention, memory, praxis as well as gross and fine motor skills, visual processing, language processing, adaptive skills, sensory and perceptual skills, and behavioral, emotional, and social functioning, which is accomplished through the use of, in most cases, all of the following methods: history and clinical interview, a flexible battery of standardized instruments, observation, and behavior/skill ratings completed by the patient, their family, and their teachers (Mahone and Slomine 2008). Many practicing child neuropsychologists believe that, because neuropsychological assessments provide thorough consideration of the full range of functional neurobehavioral domains and co-occurring conditions, and provide diverse and targeted recommendations, they have added value in promoting symptom reduction and improving the quality of life among children with ADHD and their families. Furthermore, because neuropsychological assessments typically utilize a wide variety of measurement methods in diagnosing ADHD, rather than relying on parent and teacher ratings alone, they allow for careful consideration of both cognitive (e.g., learning disabilities, language disorders) and emotional (e.g., anxiety, depression) factors that might be contributing to the child's apparent attentional or behavioral difficulties.

Compared to ADHD, however, more evidence exists supporting the utility of neuropsychological assessment for other medical conditions. For example, the epilepsy literature indicates that neuropsychological assessments are useful in localizing behavioral dysfunction, predicting seizure lateralization, providing a baseline from which to measure cognitive decline due to the epilepsy itself or the treatments for the condition (e.g., medication), and predicting cognitive outcomes following surgery (Buckley et al. 2010; Jones-Gotman et al. 2010; Keary et al. 2007). Similarly, within the realm of neuro-oncology, neuropsychological assessments have been shown to be useful in disentangling cognitive and behavioral effects of brain tumors themselves from the effects of pharmacological and surgical treatments for the tumors in order to assist with medical decision-making (Iuvone et al. 2011). Finally, neuropsychological assessments conducted after traumatic brain injury are useful in predicting long-term functional outcomes (Bercaw et al. 2011). Thus, while neuropsychological assessment has been shown to provide incrementally useful and necessary information (beyond that obtained by MRI, CT or EEG) to assist with diagnosis and management in medical conditions, there are surprisingly few data supporting the utility of neuropsychological assessment in the management of childhood ADHD.

Diagnosis of ADHD in children is complex because many symptoms observed in children with ADHD (e.g., difficulty concentrating, motor restlessness, racing thoughts, etc.) are not unique to ADHD, and are common among other emotional and behavioral disorders (e.g., learning disorders, anxiety, depression; American Psychiatric Association 2000), as well as among treatable medical conditions (e.g., thyroid dysfunction, eczema, hearing loss; Feagans et al. 1994; Hauser et al. 1993; Kooistra et al. 1996; Schmitt et al. 2009). Moreover, diagnosis of ADHD in girls is even more complicated than it is in boys, due to later age of onset, more subtle clinical manifestations, and limitations associated with the DSM-IV diagnostic nomenclature (Taylor and Keltner 2002; O'Brien et al. 2010). Although ADHD presents considerable challenges on its own, diagnosis and treatment is often significantly complicated by co-occurring emotional disorders. Data collected by the National Center for Health Statistics indicate that for children and adolescents with ADHD, the risk of an anxiety disorder is 7.45 times greater than for those without an ADHD diagnosis, the risk of depression is 8.04 times greater, the risk of an autism spectrum disorder is 8.72 times greater, and the risk of Tourette syndrome is 10.70 times greater (Larson et al. 2011). The comorbidity of ADHD and pediatric Bipolar disorder is estimated at 15% or more (Wilens and Dodson 2004) and is associated with an earlier age of onset, as well as recurrent affective episodes, suicide attempts, violence, and legal problems, compared to individuals with Bipolar disorder without ADHD (Barkley et al. 2008). In some cases, research has found significant co-occurrence between ADHD and multiple other disorders. For example, ADHD overlaps considerably with both Obsessive Compulsive Disorder (OCD) *and* Tourette syndrome (Grados et al. 2008), and the typical neuropsychological profile of children with this triad of conditions is quite complicated, with more severe deficits than would be expected of children with ADHD alone (Denckla 2006). More general motor dysfunction is also common among children with ADHD, with overlap having been found between ADHD and Developmental Coordination Disorder (estimated to co-occur in more than 50% of cases), developmental dyspraxia, and motor stereotypies (Dewey et al. 2007; Harris et al. 2008; Mahone et al. 2004; Pitcher et al. 2003).

Without ruling out other causes for behavioral and emotional symptoms, the accuracy of an ADHD diagnosis is in question, and, if the child is improperly or not thoroughly diagnosed, treatment is likely to be both less effective and more expensive. For instance, although several symptoms of depression and anxiety overlap with those of ADHD, these disorders do not typically respond well to stimulant treatment, while stimulant medication is very effective in treating ADHD (Gillberg et al. 2004). Even when the diagnosis of ADHD is accurate, if co-occurring conditions are not recognized and treated, the child's functioning may remain significantly impaired, and the (otherwise appropriate) treatments for ADHD may be less effective. For instance, children with ADHD and Developmental Coordination Disorder have very different treatment needs and worse long-term outcomes than children with ADHD alone (Rasmussen and Gillberg 2000). Failure to address co-occurring emotional, behavioral, learning and motor conditions can considerably limit the effectiveness of ADHD treatments; however, many of these conditions are not assessed as part of routine diagnosis and management of ADHD. A comprehensive neuropsychological assessment, as previously defined, evaluates all of these functional domains and generates recommendations for treatment of ADHD that consider any co-occurring conditions.

Although routine pediatric or general practitioner visits should include a broad-based evaluation of a child's overall functioning (including *both* physical and mental health; American Academy of Pediatrics Committee on Practice and Ambulatory Medicine and Bright Futures Steering Committee 2007), in current practice, these visits may not allow sufficient time for such considerations. In contrast, a thorough neuropsychological assessment will evaluate both for the presence of ADHD, and for possible alternate explanations for symptoms, in order to accurately rule out differential or co-occurring diagnoses (Board of Directors: American Academy of Clinical Neuropsychology 2007; Silver et al. 2006). Neuropsychological assessments also offer targeted recommendations spanning multiple domains, including functional (i.e., academic, social) life skill interventions; school and/or work accommodations; and evaluation and treatment recommendations (e.g., behavioral therapy, family counseling, occupational therapy, speech-language treatment, medical/pharmacological evaluation, etc.), when appropriate. By definition, neuropsychological assessments offer comprehensive recommendations addressing targeted symptoms or areas of need that include the three most critical agents of change in the child's life: family, school, and treatment providers.

The purpose of this review is threefold: 1) to examine prevalence data, diagnostic guidelines, and functional outcomes and risks associated with childhood ADHD; 2) to review current outcome data associated with treatment for childhood ADHD; and, 3) to document evidence of the utility of comprehensive neuropsychological assessment in evaluation and treatment of childhood ADHD. Specifically, this review addresses the question of whether neuropsychological assessment offers significant added benefit in the diagnosis and treatment of childhood ADHD.

Prevalence of Childhood ADHD

ADHD is characterized as a major public health problem with significant, far-reaching consequences both for affected individuals and for society as a whole (National Institute of Health [NIH] Consensus Development Panel 2000). ADHD is the most commonly diagnosed childhood psychiatric disorder, with recent estimates suggesting a prevalence of approximately 5 million children and adolescents in the United States alone (Bloom et al. 2010). Furthermore, the prevalence of ADHD is increasing. For the period of 2007–2009, an annual average of 9.0% of children had ever been diagnosed with ADHD, compared to 6.9% in 1998–2000 (Akinbami et al. 2011). Boys are diagnosed with ADHD about twice as often as girls (12.3% and 5.5% prevalence respectively; Akinbami et al. 2011). Incidence increases with age, with estimated rates of ADHD among adolescents ages 10–17 at 10.9%, as compared to 5.8% among children 5–9 years of age (National Center for Health Statistics 2011). The most recent data suggest little difference in ADHD prevalence rates between non-Hispanic white (10.6%) and black (9.5%) children; however, prevalence rates for Mexican children are considerably lower (approximately 4%; Akinbami et al. 2011).

Geographically, rates of ADHD diagnosis are significantly higher in North America than in Africa or the Middle East, but consistent with rates in Europe, South America, Asia, and Australia and the South Pacific (Polanczyk et al. 2007). Considerable geographic variability is evident in ADHD diagnostic prevalence even within the United States, with a high of more than 11% of 4–17 year olds diagnosed with ADHD in Alabama and a low of nearly 5% in Colorado (Centers for Disease Control [CDC] 2010). The South and Midwest regions of the United States currently evidence the highest prevalence rates for ADHD (10.3% and 10.2% respectively), and considerable increases in diagnostic prevalence of ADHD nationwide have been reported (Akinbami et al. 2011; CDC 2010).

In addition to demographic and geographic factors, the rate of ADHD diagnosis is associated with a variety of socioeconomic factors. For instance, in the United States, growing up in an impoverished community increases a child's likelihood of being diagnosed with ADHD, especially the Predominantly Hyperactive subtype (Froehlich et

al. 2007). Other socioeconomic risk factors related to ADHD diagnosis for children in the US include living in a family that falls within 100% (below or above) of the poverty level, living in a single parent household, and having Medicaid as opposed to private or no insurance (Akinbami et al. 2011; Bloom et al. 2010; National Center for Health Statistics 2011).

The prevalence of ADHD also varies by subtype, although interpretation of this variability is challenging, since subtypes are generally unstable and often change over time (Hinshaw et al. 2006; Lahey et al. 2005; Todd et al. 2008). Among U.S. children ages 8–15, approximately twice as many individuals are diagnosed with the Predominantly Inattentive subtype (4.3%) as with the Combined (2.2%) and Predominantly Hyperactive (2.0%) subtypes (Froehlich et al. 2007; Merikangas et al. 2010). In sum, ADHD is a strikingly prevalent and pervasive condition that cuts across a wide variety of demographic, geographic, and socioeconomic lines.

Structural and Functional Brain Differences in ADHD

Current evidence of structural and functional brain differences in ADHD clearly indicates a neural basis for the cognitive and behavioral impairments frequently seen in this disorder. Structural differences among children with ADHD include total brain volume (Castellanos et al. 1996), and delayed cortical maturation, particularly within frontal and temporal brain regions (Shaw et al. 2007), as well as abnormalities within the corpus callosum, prefrontal regions, temporal and parietal cortex, and basal ganglia (Filipek et al. 1997; Giedd et al. 1994; Hill et al. 2003; Sowell et al. 2003). A review of the available evidence suggests that anomalous basal ganglia development remains the most consistent finding across samples and imaging methodologies (Nakao et al. 2011), and this, in combination with the widespread cerebellar and cortical delays, is associated with the behavioral (cognitive, motor, oculomotor) phenotype of children with ADHD. These motor and 'executive' control systems appear to develop in parallel, such that both systems display a similar protracted developmental trajectory, with periods of rapid growth in elementary years and continued maturation into young adulthood. The neuroanatomic anomalies observed in children with ADHD set the stage for deficits in motor and oculomotor coordination and speed, which, when carefully assessed, are ubiquitous to the disorder and contribute to persistent cognitive and academic dysfunction. Conversely, when not carefully assessed, these deficits often go overlooked and unmanaged, potentially leading to suboptimal treatment. For example, children with ADHD commonly exhibit deficits in controlled behavior including difficulties with inhibition and temporal processing, as well as delay aversion (Sonuga-Barke and Halperin 2010). These components of controlled behavior are supported by a distributed neural network with cortical and subcortical components, including the frontal cortex and its striatal-thalamic-cerebellar connections (Durston et al. 2010), which have been identified as among the most anomalous networks in ADHD. Frontal projections to the basal ganglia and cerebellum form a series of frontal-striatal-thalamo-frontal and frontal-cerebello-(dentato)-frontal circuits (Krause et al. 2002). These circuits link specific regions of the frontal lobes to subcortical structures, supply modality-specific mechanisms for interaction with the environment, and provide the framework for understanding the neurobiological substrate of ADHD. Taken together, these findings of structural and functional developmental brain differences in ADHD clearly emphasize that the involvement of multiple neural systems contributes to very complex and interconnected cognitive, motor, and behavioral/emotional symptoms of the disorder.

Given these considerations, comprehensive assessment of childhood ADHD, especially for the child's initial assessment, requires an understanding of these brain-behavior relationships. Highly salient conditions that coexist with ADHD simply may not be assessed without completion of a comprehensive neuropsychological examination. As noted, one such condition is motor dysfunction, including Developmental Coordination Disorder (DCD), with as much as 50% comorbidity in boys with ADHD (Pitcher et al. 2003), with research suggesting a very different set of risk factors, treatment needs, and outcomes than children with ADHD without DCD (Rasmussen and Gillberg 2000). Children with ADHD are also at higher risk for developmental dyspraxia (Steinman et al. 2010), especially if they also have DCD (Dewey et al. 2007). Failure to assess for dyspraxia can also lead to incomplete treatment, and a misunderstanding of why (for example) the child with ADHD without other learning difficulties is making poor progress in the development of writing skills, which are dependent on limb kinetic praxis (Heilman et al. 2000; Martin et al. 2010).

Inherent Difficulties with Behaviorally-Based Diagnoses for Clinical Neuropsychology

In the clinical setting, child neuropsychologists use two general approaches to classification of childhood disorders—one emphasizing *behavior*, and the other emphasizing *neurology* (Mahone and Slomine 2008). The extant research literature has increasingly emphasized investigations of the neurologic correlates of behaviorally defined developmental conditions (e.g., ADHD); while at the same time, there has been a search for behavioral phenotypes among genetic and

neurologic disorders (Denckla 2000). From the purely behavioral perspective, developmental disorders are classified on the basis of behavioral or cognitive symptoms alone, often regardless of etiology. Although the majority of these disorders are presumed to have their basis in the brain, the observed dysfunction does not always map directly onto the behavioral diagnosis. Thus, children with known neurological disorders can display one or more of these Diagnostic and Statistical Manual, Fourth Edition-Text Revision (DSM-IV-TR; American Psychiatric Association 2000) behaviorally defined disorders. When they do, the behavioral diagnoses imply little about the etiology of the condition. More often, however, children with known neurologic impairment manifest *symptoms* of several behavioral disorders, but do not fit neatly into the full diagnostic criteria for a single disorder. Furthermore, the behaviorally-based diagnostic criteria found in the DSM-IV-TR rarely provide adequate consideration of the developmental nature of many disorders of childhood, such as ADHD. Consider the example in which a child presents with severe executive dysfunction, as well as deficits in motor control and emotional dysregulation, but does not meet DSM-IV-TR criteria for a diagnosis of ADHD, or a motor or mood disorder. A comprehensive neuropsychological assessment offers a thorough consideration of *all* of the presenting symptoms, based on an understanding of brain structure and function, thus transcending behaviorally-based diagnostic formulations and allowing for a richer understanding of the interconnections among symptom patterns, leading to more effective treatment recommendations.

The Diagnosis of ADHD within Primary Care Settings

At least half of individuals with ADHD are identified and treated within primary care settings, rather than by a mental health professional (Epstein et al. 2008; Leslie et al. 2006; Leslie et al. 2004). For most children, pediatricians or family physicians provide primary care. Formal guidelines for the diagnosis of ADHD tend to be fairly consistent across primary care settings and focus on the characteristics of the DSM-IV-TR (American Psychiatric Association [APA] 2000) and ICD-10 (World Health Organization [WHO] 2004) criteria for the disorder. The American Academy of Pediatrics (AAP) guidelines for assessment and diagnosis of ADHD include: 1) documentation of DSM-IV criteria; 2) evidence of core symptoms of ADHD manifested both at home and school; and, 3) evaluation of possible coexisting conditions (Olson et al. 2005). Similarly, the American Academy of Child and Adolescent Psychiatry (AACAP) practice parameters for diagnosis of ADHD include: 1) clinical interviews with the parent and patient; 2) review of information about the child's functioning in school; 3) evaluation of comorbid psychiatric disorders; and 4) review of the patient's medical, social, and family history. These guidelines further specify that, while psychological or neuropsychological tests are not mandatory for the diagnosis of ADHD, they should be performed if the patient's history is suggestive of low cognitive abilities or low academic achievement. These guidelines specify some of the core components of a neuropsychological evaluation for ADHD and may, in *some* cases, be adequate for the assessment of ADHD *if* they are explicitly followed (American Academy of Child and Adolescent Psychiatry 2007).

Unfortunately, published research suggests that adherence to the AAP guidelines is poor within primary care settings. Although 80% of pediatricians use formal diagnostic criteria to assess ADHD, only 25% use the actual DSM-IV criteria and only 67% of pediatricians employ standardized rating scales in making the diagnosis (Wolraich et al. 2010). Although published research indicates that the majority (77%) of primary care physicians are familiar with the AAP guidelines (with more pediatricians reporting familiarity than family physicians), only 61% reported incorporating the guidelines into their practice (Rushton et al. 2004). Of note, most physicians in this study reported utilizing individual components of the AAP guidelines when diagnosing ADHD in their practice, but few (26%) made use of all of them, with use of DSM-IV criteria falling below 50%. Similarly, only 4% of pediatricians, pediatric residents, and nurse practitioners within a university-based pediatric outpatient clinic adhered to all four of the AAP guidelines when diagnosing children with ADHD (Olson et al. 2005). Finally, more recent evidence suggests that only 38% of children with a diagnosis of ADHD have any type of documentation providing evidence of adherence to the DSM-IV criteria and only slightly more than half were evaluated using any type of parent and/or teacher rating scales (Epstein et al. 2008).

Two key factors appear to contribute to the poor adherence to diagnostic guidelines in primary care settings. First, many pediatricians receive limited mental health training (Dulcan et al. 1990; Keevil 1997; Kush and Campo 1998; Long et al. 1994). Second, and of increasing concern, even those who have been adequately trained are not likely to have sufficient time in routine visits to conduct an assessment that would adhere to guidelines. The length of the average patient visit is approximately 12–20 min in pediatric primary care settings (Cox et al. 2007; Phillips et al. 1998; Rattay et al. 2004), and physicians have identified insufficient time as a significant impediment to management of patients' psychosocial concerns (Heneghan et al. 2008; Kush and Campo 1998; Rushton et al. 2002). Even if the full 15-minute visit were to be devoted entirely to the assessment of ADHD, this period of time would not be adequate to accomplish even a careful diagnostic interview

with parents, ruling out possible co-occurring disorders, not to mention obtaining collateral sources of information or performing a clinical interview with the child.

In sum, although guidelines for diagnosis of ADHD have been clearly set forth, adherence to these guidelines as part of routine primary care is alarmingly low. Given that most individuals with ADHD are identified as such within primary care settings, this finding calls into question the accuracy and completeness of diagnosis for the majority of individuals with ADHD.

Use of Psychometric Tests in the Diagnosis of ADHD

The American Academy of Pediatrics' guidelines for the assessment of ADHD clearly reflect the behavioral basis of the DSM-IV and ICD-10 definitions of the disorder. These guidelines largely ignore the contributions that neuropsychological measurement instruments can make in helping to confirm, disconfirm, and/or refine diagnoses. Acknowledging that ADHD is a behavioral diagnosis, likely arising from multiple etiologies (Willcutt et al. 2010b), it is recognized that psychological and neuropsychological tests alone are not sufficient to make the diagnosis. By current diagnostic standards, the behavioral diagnosis of ADHD is made *by exclusion*—only after other conditions that could explain the pattern and duration of the child's symptoms have been ruled out—medically (e.g., hearing loss), cognitively (e.g., intellectual disability or language disorder), psychosocially (e.g., situational stress), and psychiatrically (e.g., anxiety disorders). Moreover, in children, it is critical to note that ADHD occurs more often *with* comorbidities, and uncomplicated ADHD (i.e., without comorbidities) is the exception, rather than the rule (Larson et al. 2011). For instance, among children with ADHD, approximately 35–40% have a comorbid diagnosis of dyslexia (Specific Reading Disability; Willcutt et al. 2010a), which, by DSM-IV criteria, *requires* psychometric assessment for diagnosis. Considering *only* the other forms of specific learning disabilities—all of which require psychometric assessment for diagnosis—(i.e., Mathematics, Written Expression), the co-existence of ADHD with Learning Disabilities alone approaches 60% (Larson et al. 2011). The co-occurrence of ADHD and learning, mood, and anxiety disorders also highlights the limitations of reliance on rating scales as such a central component of diagnosing the disorder. In particular, individuals such as parents and teachers tend to underreport (relative to children and adolescents' self-ratings) both internalizing and externalizing symptoms (Van der Ende et al. 2011). Additionally, the poor inter-rater reliability between parents and teachers (Murray et al. 2007) suggests that a child's behavior is likely to differ depending on the demands of the setting, but might also point to the inherent difficulty in accurately identifying someone else's internal states. For instance, a child who is rated high on inattention by his teacher may, indeed, be inattentive in the classroom setting; however, this symptom may be the result of an anxiety disorder rather than ADHD.

So, although standardized psychometric tests alone are not sufficient for making reliable diagnoses of ADHD, use of these tests may increase the validity of diagnostic decision-making when used in combination with a thorough review of the child's history, diagnostic interviews, parent and teacher ratings, and direct observation. Further, because ADHD is heterogeneous in its neurobehavioral phenotype (Goos et al. 2009; Wehmeier et al. 2010), a thorough description of the child's cognitive strengths and weaknesses is crucial for making appropriate recommendations regarding treatment and accommodations (Mahone and Slomine 2008).

Several studies have questioned the utility of neuropsychological assessment instruments, particularly those designed to measure executive functions, in making diagnostic classifications (Doyle et al. 2000; Grodzinsky and Barkley 1999; Perugini et al. 2000), though even these studies recognize the important role that neuropsychological tests can have in elucidating individuals' strengths and weaknesses related to attention specifically and cognition in general. While the literature on the predictive power and sensitivity/specificity of neuropsychological measures is mixed, several measures (e.g., go/no-go, Stroop, divided attention, and continuous performance tasks) have been shown to consistently differentiate children with ADHD from controls (Berlin et al. 2004; Harris et al. 1995; Kaufmann et al. 2010; Wada et al. 2000) and from children with other conditions (e.g., high functioning autism; Mahone et al. 2006). Further, emerging research suggests that select neuropsychological test batteries may be even more sensitive and specific for diagnosis of ADHD than any one individual measure alone (Gupta et al. 2011; Hale, et al. 2009).

Outcomes Associated with Childhood ADHD

ADHD is associated with extraordinary costs, not only for those living with the disorder and their families, but also for society as a whole. These costs, described below, range from individual deficits in social and academic realms to pronounced losses in economic and social welfare.

Social Costs of ADHD Many children with ADHD experience marked deficits in social functioning, which often continue to cause problems throughout adolescence and adulthood. At the foundation, social cognition seems to be impaired among children and adolescents with ADHD.

Children with ADHD struggle with identifying causal relationships in social situations (van den Broek 1997) and with generating effective solutions to hypothetical social problems (Zentall et al. 2001). Adolescents with ADHD also commonly show deficits in social comprehension and attribution, as well as social problem solving (Sibley et al. 2010). Social functioning may also be impacted by deficits in executive functions, which are estimated to affect approximately half of individuals with ADHD (Miller and Hinshaw 2010). Individuals with ADHD who have greater executive dysfunction in childhood tend to be less preferred by peers in adolescence (Miller and Hinshaw 2010). This relationship between executive function and social functioning may be even more pronounced among girls (Diamantopoulou et al. 2007).

Specific skill deficits with regard to social interactions have also been identified among children with ADHD. Children and adolescents with ADHD commonly demonstrate lower levels of prosocial behaviors, such as sharing, turn-taking, and cooperation (Barkley 2006); however, they also show higher levels of problematic social behaviors, such as impulsivity, intrusiveness, aggression, and hostility (Wehmeier et al. 2010). As a result, children and adolescents with ADHD have fewer reciprocal friendships (Hoza et al. 2005), few close friends (Wehmeier et al. 2010), and experience greater peer rejection (Hoza et al. 2005). In part because they have difficulty being accepted within typical peer groups, adolescents with ADHD are at increased risk for association with deviant peers (Barkley 2006; Marshal et al. 2003). The consequences of affiliation with a deviant peer group are well established, and this affiliation may contribute to some of the negative behavioral outcomes associated with ADHD, such as substance use and delinquency (reviewed below).

In addition to deficits in peer relationships, children and adolescents with ADHD often exhibit considerable dysfunction within the family realm. Children with ADHD tend to experience more conflict with their parents (Barkley 2006), and parents of these children report greater stress, poorer coping, and loss of confidence in their parenting skills (Cunningham 2007). Their parents are also more likely to experience marital conflict and to divorce (Wymbs et al. 2008). Further, as romantic relationships become increasingly salient in adolescence and adulthood, individuals with ADHD continue to struggle. Adolescents with ADHD begin sexual activity at an earlier age, have more sexual partners, are less likely to use contraception, and are more likely become pregnant or contract a sexually transmitted disease than teens without ADHD (Barkley 2006). Adults with ADHD tend to have less stable romantic relationships and are more likely to separate or divorce (Biederman et al. 2006; Weiss and Murray 2003).

Academic and Vocational Costs of ADHD Children with ADHD are at increased risk for numerous negative academic outcomes, and are more likely to perform poorly overall in school (Barkley 2006). Compared with typically developing children, those with ADHD are more likely to receive special education services, be retained at higher rates, drop out of school, have a lower grade point average, and receive more suspensions and expulsions (Barkley 2006; Faraone et al. 1993; Fletcher and Wolfe 2008). Among those adolescents with ADHD who do successfully complete high school and move on to college, many struggle with the increase in independence and decrease in structure within the setting of higher education. College students with ADHD have been found to have poor organizational and time-management skills, use inefficient test-taking strategies, and struggle with procrastination (Reaser et al. 2007; Weyandt and DuPaul 2006; Turnock et al. 1998). As a result of these difficulties and the increased demands of the college setting, college students with ADHD are at risk for earning lower grades (Norwalk et al. 2009; Spinella and Miley 2003). In part because of lower high school graduation rates and lower college achievement, individuals with ADHD subsequently experience poorer employment outcomes as adults (Barkley 2006). Specifically, they are less likely to work in a professional job setting, experience more changes in employment, are late or absent from work more often, and are at higher risk for being terminated from their jobs as compared to adults without ADHD (De Quiros and Kinsbourne 2001; Kessler et al. 2006; Kleinman et al. 2009; Murphy and Barkley 1996; Weiss and Hechtman 1993). As a result, adults with ADHD tend to attain lower socioeconomic status than those without ADHD (Barkley 2006).

Societal Costs of ADHD: Substance Use and Criminal Activity It is now widely recognized that adolescents with ADHD, especially those with co-occurring ODD, are at increased risk for substance abuse. This includes increased likelihood of cigarette use, as well as greater prevalence of substance and alcohol use disorders (Bussing et al. 2010; Charach et al. 2011; Wilens 2011). Worse yet, individuals with ADHD tend to develop substance use disorders earlier, evidence heavier cigarette smoking and substance use, and have greater difficulty with cessation than those without the disorder (Bussing et al. 2010; Wilens 2011). Co-occurring externalizing behavior disorders (e.g., Oppositional Defiant Disorder, Conduct Disorder) seem to partially mediate the association between ADHD and substance use (August et al. 2006, Barkley et al. 2004, Molina and Pelham 2003). The link between ADHD and substance abuse has been further supported by functional imaging studies implicating frontal-subcortical systems and anterior cingulate in both disorders; and several genes that have been identified as

likely contributors to ADHD seem to also be relevant for substance use disorders (Wilens 2011). Further, neuropsychological deficits, such as poor vigilance, motor speed, response inhibition, verbal learning, and working memory, have been found in both adults with ADHD and those with substance use disorders (Seidman 2006).

It is not surprising then, given the comorbidity between ADHD, substance use disorders, and Conduct Disorder/ODD, that individuals with ADHD are at heightened risk for involvement in delinquent and criminal activity. Having ADHD or even subthreshold ADHD (i.e., fewer than 6 symptoms in a given area, with significant impairment) in childhood has been found to triple or, in some cases quadruple the odds of juvenile justice system involvement, regardless of gender or race (Bussing et al. 2010; Moffitt and Silva 1988). Indeed, males with elevated symptoms of hyperactivity/impulsivity are more likely to engage in property crimes and crimes of 'public disorder,' and are more likely to be arrested, due to their impulsive nature and difficulty delaying gratification (Babinski et al. 1999). As with substance use, children with ADHD tend to begin engaging in criminal activity at an earlier age than their typically developing peers (Lahey et al. 1999). The development of a substance use disorder or antisocial behavior disorder in adolescence appears to play a mediating role in the link between childhood ADHD and criminal activity (Mannuzza et al. 2008).

Societal Costs of ADHD: Economic and Health Care Utilization Children with ADHD utilize the health care system more often and incur higher costs than children without the disorder. Pelham et al. (2007) concluded that "a preliminary, incomplete, and conservative estimate of the annual Cost of Illness (COI) of ADHD is $14,576 per child in 2005 dollars….this translates into a minimum annual aggregate COI of $42.5 billion, with a more likely estimate being twice that amount." This figure is only slightly less than the annual COI for anxiety disorders (estimated at $63.2 billion, when adjusted to 2005 dollars; Greenberg et al. 1999; U.S. Bureau of Labor Statistics 2011), but is higher than the annual COI for autism (which is estimated at $33 billion, when adjusted to 2005 dollars; Ganz 2007; U.S. Bureau of Labor Statistics 2011). Individuals with ADHD also incur medical and pharmaceutical costs at a rate of nearly three times those without the disorder, according to insurance and employment records, due to increased primary care, hospital, and pharmaceutical costs (Swensen et al. 2003). Additionally, family members of individuals with ADHD also show substantial increases in costs associated with disability and absenteeism. Children with ADHD are significantly more likely to be admitted to the emergency room and hospitalized (Leibson et al. 2001). Not only are children with ADHD more likely to be hospitalized, but their injuries tend to be more severe than those of children without ADHD, with many of these injuries potentially related to their impulsivity (pedestrian, bicycle, motor vehicle, and fall injuries; DiScala et al. 1998). Among hospitalized children, those with ADHD have longer stays and higher total costs than do hospitalized children without ADHD (Meyers et al. 2010). As adolescents and young adults, individuals with ADHD are more likely to be reckless drivers, to receive citations and have their licenses suspended, and to incur more severe injuries due to motor vehicle accidents while driving (Barkley and Cox 2007; Barkley et al. 1993; Woodward et al. 2000; Barkley 2002; Weiss and Murray 2003). Birnbaum and colleagues (2005) estimate that the considerable majority (approximately 75%) of the health care costs incurred by individuals with ADHD can be attributed to the treatment of co-occurring conditions, rather than the treatment of the ADHD itself, which only accounts for 10% of these costs.

The cost of comprehensive neuropsychological assessment in the care of children with ADHD undoubtedly contributes to reluctance on the part of third-party payors to authorize such services; however, when contrasted with the aforementioned figures, the cost of such services is minute. Because a neuropsychological assessment can elucidate a child's strengths and weaknesses, provide a good differential diagnosis, and recommend appropriate and thorough interventions, considerable savings can be expected, both for the individual with ADHD and society as a whole.

Quality of Life (QoL) in ADHD Given the number of negative outcomes associated with ADHD, it is not surprising that quality of life (QoL) is reduced as well. Individuals with ADHD, as compared with their typically developing peers, show robust statistically and clinically significant decreases in multiple domains of QoL (Danckaerts et al. 2010). In particular, psychosocial and achievement-related aspects of QoL seem to be affected among this group, and neither gender nor ADHD subtype seems to moderate this association. Parents tend to report that their children with ADHD experience poorer QoL than do the children themselves; however, youth with ADHD often self-report QoL deficits as well. In addition to the impact on their child's quality of life, parents of children with ADHD report that aspects of their own quality of life, as well as family functioning, are impacted by their child's symptoms (Hakkaart-van Roijen et al. 2007). In comparison with children with chronic physical conditions (e.g., asthma), children with ADHD experience equal, and sometimes even greater, reductions in many QoL domains (Danckaerts et al. 2010; Escobar et al. 2005). Finally, children with ADHD who also have a co-occurring disorder appear to experience even greater QoL deficits relative to their ADHD-only peers (Klassen et al. 2004; Newcorn et al. 2005).

Does ADHD Treatment Improve Outcomes?

There are several types of treatments available to address symptoms of ADHD and related functional impairments. The most common, by far, is stimulant medication, followed by psychotherapeutic treatments and educational support services. Many of these treatments result in statistically significant decreases in symptomatology and, in some cases, in functional improvement; however, across the board, studies clearly indicate that treatment for this population is not being optimized, as many individuals with ADHD continue to show both symptoms and functional impairment despite receiving treatment (e.g., Hechtman 2005; Langley et al. 2010; The MTA Cooperative Group 1999). In the large-scale MTA studies, although significant improvements in symptomatology were found initially, many of these positive results dissipated quickly (Molina et al. 2009). At short-term follow-up, the combined and medication management groups showed higher symptom reduction than did the multi-component behavior therapy and usual community care groups. However, half of this initial advantage had disappeared at the 10-month follow-up, and by the 22-month follow-up (as well as at the 6- and 8-year follow-ups) no significant treatment group differences remained and MTA participants performed worse than their typically developing peers in nearly all areas assessed (Molina et al. 2009). The absence of treatment group differences in the long term was not simply a result of declining medication use in the post-study period. In fact, Molina and colleagues (2009) reported that use of medication either was not associated or was *negatively* associated with almost all of their outcome measures. These findings suggest that, when the *intensity* of treatment is decreased, symptoms and functional impairment return for children with ADHD; thus, these treatments may not be targeting all of the appropriate domains (or disorders) necessary to create longstanding change. Further, many individuals' needs may not be effectively addressed using current treatments for ADHD. More than 30% of participants with ADHD who received treatment as part of the MTA study did not achieve remission (defined as "a clinically satisfactory response of near normalization;" The MTA Cooperative Group 1999). Among children and adolescents with ADHD receiving treatment as usual, approximately 70% continued to meet criteria for a diagnosis of ADHD after 5 years, despite the fact that 93% had been treated with stimulants at some point during that period (Langley et al. 2010). Similarly, remission rates at 4 and 8 weeks, following treatment with two stimulant medications, ranged from 14% to 44%, indicating that the majority of treated individuals do not achieve symptom remission (Hechtman 2005).

Recent reviews of the effects of medication treatment of ADHD share the general conclusion that treatment with medication has the potential to reduce symptoms and high-risk behaviors and improve quality of life, though not consistently or completely (Biederman et al. 1999; Coghill 2010; Danckaerts et al. 2010; Frazier et al. 2010). In addition, although psychopharmacological treatments for ADHD reduce core symptoms of ADHD, they do not normalize co-occurring impairments, such as reading difficulties, parent–child relationships, social skill deficits, or oppositional-defiant behavior (Loe and Feldman 2007).

While considerable evidence exists for the effectiveness of *behavioral* treatments in reducing core ADHD symptoms and improving co-occurring impairments (e.g., social skills), effect sizes (which range from low to high across studies and outcomes of interest) indicate that these treatments are neither totally effective nor effective for all individuals (Fabiano et al. 2009; Pelham and Fabiano 2008; van der Oord et al. 2008). These findings suggest that even when individuals with ADHD do experience a reduction in symptoms, if treatment is not specifically designed to address other areas of impairment or concern, quality of life and life satisfaction will still be impacted. Neuropsychological assessment, then, has the potential to offer a better understanding of ADHD-specific symptomatology, co-occurring disorders, and the individual's particular strengths and weaknesses in order to make recommendations for *optimizing* treatment to address all of these factors.

Beyond behavioral and pharmacologic treatments for ADHD, accommodations made in the academic setting offer the invaluable opportunity to "level the playing field" for children with ADHD. Students with ADHD can benefit from accommodations such as small group instruction (Hart et al. 2011) and computer-based testing (Lee et al. 2008). Also, given the considerable overlap between ADHD and learning disabilities and motor dysfunction, accommodations that are effective for these co-occurring conditions (e.g., reading tests aloud to children with reading disabilities; Tindal et al. 1998) are likely to benefit many children with ADHD. With help, students can learn to apply the same accommodations that they receive at school to their study habits at home in order to allow them to complete homework or work on longer projects more successfully. Following comprehensive assessments, neuropsychologists are in a unique position to recommend accommodations that are specific and tailored to the student's learning strengths and weaknesses in order to most effectively help to "level the playing field" for the student.

Summary & Conclusions

The preceding review highlights three points that are now well-established: 1) ADHD is one of the most common disorders of childhood; 2) ADHD is associated with considerable deficits in social, emotional, and academic

functions, as well as quality of life; and, 3) ADHD is extremely costly to society as a whole, both economically and socially. These facts underscore the importance of understanding and treating this disorder more effectively. Diagnosis of ADHD is complicated by the fact that ADHD more often than not co-occurs with other disorders and the core symptoms of ADHD are common to a wide variety of other disorders. Compounding this issue, the diagnosis of ADHD is most commonly made by primary care physicians who often lack adequate time and training to follow the recommended (published) diagnostic guidelines. Further, the available literature indicates that pharmacologic and behavioral treatments for ADHD can reduce core symptoms of the disorder; however, 1) results may be short-lived, 2) improvements may not extend to areas of impairment beyond core symptoms, 3) these treatments are not effective for all individuals, and 4) many individuals do not achieve full remission of symptoms even with evidence-based treatments. The current diagnostic structure of ADHD is behaviorally based and does not *require* psychometric testing; however, neuropsychological measures and batteries have been shown to reliably differentiate children with the disorder from those without and can assist with reliable diagnosis of co-occurring disorders. Therefore, it is our position that a thorough neuropsychological assessment (as defined herein) of children suspected of having ADHD can offer the following incremental benefits:

1. Use of a wide variety of measures (rather than just parent or teacher report) to capture a thorough understanding of a child's neurobehavioral, cognitive, emotional, and social strengths and needs;
2. Thorough consideration of co-occurring psychological, academic, cognitive, and medical conditions, including the known behavioral implications of brain-based anomalies in ADHD;
3. Diverse and targeted recommendations related to intervention and accommodation, both for the symptoms of ADHD itself and for co-occurring disorders, which span multiple domains; and,
4. Provision of a psychometrically-defined baseline level of functioning against which treatment effects and developmental progress can be measured.

As a result, neuropsychological assessment for ADHD can potentially offer a more accurate and thorough diagnostic formulation than diagnostic methods that do not include a neuropsychological assessment. Treatment based on a more accurate and thorough formulation is likely to be more effective, as it can make optimal use of a child's individual strengths, be targeted to a child's specific symptomatology, and address any co-occurring conditions or difficulties. More effective treatment for ADHD, in turn, has the potential to reduce both personal and societal costs related to the disorder. Although the financial costs of neuropsychological assessments are often cited as a limiting factor, this view seems shortsighted, given the potential economic, societal, and personal benefits to be reaped from such evaluations in the long run.

Careful review of the evidence suggests that neuropsychological assessments can contribute to more accurate diagnosis and more effective treatment of ADHD; however, studies specifically designed to address this question directly are sorely lacking. Well-designed and controlled research investigating the specific impact of neuropsychological assessment on the psychological, social, academic, and functional well-being of ADHD children and their families is needed. Such research should continue to address the validity and utility of using individual and/or groups of psychometric tests in making the diagnosis of ADHD. However, a thorough neuropsychological assessment involves much more than psychometric testing alone. The careful assessment, normative comparisons, targeted treatment recommendations, and family-focused feedback can support improved quality of life for both children with ADHD and their families. More importantly, then, future studies must address the effect of the neuropsychological assessment *as a whole* on the lives of children with ADHD, their families, and society at large. Specifically, a longitudinal comparison of children with ADHD who have received a neuropsychological assessment to those receiving routine community care for ADHD (i.e., children diagnosed and treated by their primary care pediatricians) would represent a start. Comparing symptom severity, quality of life, academic, emotional, and behavioral functioning over the course of both short- and long-term intervals for these two groups would offer preliminary information regarding effectiveness. In order to demonstrate a causal relationship, however, randomized, longitudinal studies comparing these two groups would be necessary. Inclusion of family-related functioning and quality of life variables in these studies would offer further insight into the far-reaching consequences of living with the symptoms of ADHD. Additional research comparing these two groups on healthcare- and treatment-related costs will be critical as well in order to demonstrate the incremental economic savings resulting from more accurate diagnosis and more appropriate, comprehensive, and individualized treatment among the group of ADHD children who receive neuropsychological assessments.

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