Does Neuropsychological Test Performance Discriminate between Epilepsy and ADHD in Children?

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Pacific University

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Does Neuropsychological Test Performance Discriminate between Epilepsy and ADHD in Children?

Abstract
Epilepsy and Attention-Deficit/Hyperactivity Disorder (ADHD) are associated with similar neuropsychological, educational, and psychosocial dysfunction, regardless of diagnostic classification of the epilepsy or subtype of the ADHD. The purpose of this archival study was to determine whether neuropsychological cluster scores could discriminate between epilepsy and ADHD in this child clinical sample, whether the clusters yield discriminant predictive accuracy. Several researchers have demonstrated an increased likelihood of impaired neuropsychological functioning in children with seizure disorders and children with ADHD as compared to their typically developing peers. Several researchers have demonstrated that children with epilepsy are much more likely to have ADHD than children without seizures. Test scores from 427 screening batteries of neuropsychological tests administered to patients ages 6 to 17 were gathered from the archives of a psychologist’s private practice in McMinnville, Oregon. The Parent Report of Psychosocial Functioning Cluster reflected weak discriminant predictive accuracy in assigning subjects to the Epilepsy, ADHD, and Epilepsy and ADHD groups, whereas there was no significant relationship between these diagnoses and the General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, and Academic Achievement Clusters in this sample. Current results support the utility of garnering a thorough developmental history and report of current functioning from a parent or caregiver.

Degree Type
Dissertation

Degree Name
Doctor of Psychology (PsyD)

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Subject Categories
Psychiatry and Psychology

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DOES NEUROPSYCHOLOGICAL TEST PERFORMANCE DISCRIMINATE BETWEEN EPILEPSY AND ADHD IN CHILDREN?

A DISSERTATION
SUBMITTED TO THE FACULTY
OF
SCHOOL OF PROFESSIONAL PSYCHOLOGY
PACIFIC UNIVERSITY
FOREST GROVE, OREGON

BY
ALISON N. SHANNON, M.S.

IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE
OF
DOCTOR OF PSYCHOLOGY

JULY 27, 2007

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ABSTRACT

Epilepsy and Attention-Deficit/Hyperactivity Disorder (ADHD) are associated with similar neuropsychological, educational, and psychosocial dysfunction, regardless of diagnostic classification of the epilepsy or subtype of the ADHD. The purpose of this archival study was to determine whether neuropsychological cluster scores could discriminate between epilepsy and ADHD in this child clinical sample, whether the clusters yield discriminant predictive accuracy. Several researchers have demonstrated an increased likelihood of impaired neuropsychological functioning in children with seizure disorders and children with ADHD as compared to their typically developing peers. Several researchers have demonstrated that children with epilepsy are much more likely to have ADHD than children without seizures. Test scores from 427 screening batteries of neuropsychological tests administered to patients ages 6 to 17 were gathered from the archives of a psychologist's private practice in McMinnville, Oregon. The Parent Report of Psychosocial Functioning Cluster reflected weak discriminant predictive accuracy in assigning subjects to the Epilepsy, ADHD, and Epilepsy and ADHD groups, whereas there was no significant relationship between these diagnoses and the General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, and Academic Achievement Clusters in this sample. Current results support the utility of garnering a thorough developmental history and report of current functioning from a parent or caregiver.
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INTRODUCTION

Epilepsy and Attention-Deficit/Hyperactivity Disorder (ADHD) are associated with neuropsychological, educational, and psychosocial dysfunction, regardless of diagnostic classification of the epilepsy or subtype of the ADHD. Reasons for impairment include underlying neuropathologies, psychosocial issues, side effects of medications designed to treat the disorders, and disordered or dysfunctional neuronal discharges (Kwan & Brodie, 2001; Aldenkamp & Arends, 2004a). In children with epilepsy, ictal and postictal effects may also be contributing to cognitive dysfunction. Given the neurological and psychosocial vulnerability of those with epilepsy and ADHD, the high rate of comorbidity is not surprising.

Because of incremental probability of impairments, children with seizure disorders or ADHD often receive neuropsychological evaluations. The evaluations assist in differential diagnosis (perhaps to determine whether symptoms are a result of short non-convulsive epileptic seizures versus ADHD), determine cognitive strengths and weaknesses, and aid in treatment planning. It is therefore crucial that neuropsychologists are familiar with expected neuropsychological functioning in each disorder.

A number of researchers have examined neuropsychological functioning in children with epilepsy or ADHD and even demonstrated overlapping neuropsychological profiles in the two disorders. Others have used discriminant analysis to differentiate between children with ADHD and normal controls (Pineda, Ardilla, & Rosselli, 1999). However, none that we are aware of have used discriminant analyses to differentiate the
disorders using clusters of neuropsychological, academic achievement, and psychosocial functioning measures.

The purpose of this archival study was to determine the whether neuropsychological cluster scores could discriminate between epilepsy and ADHD in this child clinical sample, or whether the clusters yield any discriminant predictive accuracy at all. The proposed hypotheses in the present study are that there are meaningful differences between the neuropsychological profiles of ADHD and epilepsy that can be detected with discriminant analyses and that these differences are accounted for by differences in cluster scores.
REVIEW OF THE LITERATURE ON THE NEUROPSYCHOLOGY OF EPILEPSY AND ADHD

The neuropsychological profiles and psychological functioning of individuals with epilepsy and Attention-Deficit/Hyperactivity Disorder (ADHD) have been examined by a number of researchers. Descriptions, prevalence rates, and neuropsychological findings regarding each disorder, followed by comparability and comorbidity considerations, are summarized below.

Epilepsy

In 2005, the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE) accepted the definition of "epilepsy" as "a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures and by the neurobiologic, cognitive, psychological, and social consequences of this condition." At least one epileptic seizure is required for a diagnosis of epilepsy. An epileptic seizure is defined as "a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain" (Fisher et al., 2005).

Epilepsy is the most common neurological disorder in children (Williams & Sharp, 2000). Prevalence rates in children range from 1.5 to 121/1,000, although most research estimates the rate to be between 3 and 6/1,000 (Eriksson & Koivikko, 1997), or 0.5 to 1.0% of the population (Shinnar & Pellock, 2002). Epilepsy is slightly more common in boys than girls (Williams & Sharp, 2000).
Several researchers have demonstrated an increased likelihood of impaired neuropsychological functioning in children with seizure disorders as compared to their peers without seizures (Aldenkamp, van Bronswijk, Braken, Diepman, Verwey, & van den Wittenboer, 2000; Henkin et al., 2003; Parrish et al., 2007; Schoenfeld et al., 1999). In a Finland population-based study, Sillanpää (1992) concluded that children with epilepsy are 22 times more likely than their peers to demonstrate some form of neuropsychological disability.

Proposed reasons for and likelihood of potential neuropsychological impairment in children with epilepsy include seizure frequency, seizure disorder type, underlying pathophysiology of the epilepsy, brain pathology, either causal of or secondary to the epilepsy, side effects of antiepileptic medications, and subclinical discharges causing transitory cognitive impairment (Binnie, 2001; Sánchez-Carpintero & Neville, 2003).

Despite the heterogeneity of seizures and the individuals who suffer from them, researchers have found neuropsychological trends within the population. Expected psychological functioning in children and adolescents with epilepsy will be discussed in the following order of domains: General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, Academic Achievement, and Parent Report of Psychosocial Functioning.

General Intelligence

A number of researchers have demonstrated lower Full Scale Intelligence Quotients (FSIQ) in children with epilepsy (Bjornaes, Stabell, Henriksen, and Loyning, 2001; Nolan et al., 2003; Pavone et al., 2001), although not all are in agreement with lower measured intellectual level in children with epilepsy (Hauser & Hesdorffer, 1990).
Developers of the Wechsler Intelligence Scale for Children, Third Edition (WISC-III), the most widely used measure of cognitive abilities in children, administered the test battery to 20 children with epilepsy aged 6-16 years and found that their FSIQ scores fell significantly below the expected mean with an average standard score of 74.3 and a standard deviation of 22.4 (Wechsler, 1991).

Nolan et al. (2003) examined the intellectual functioning of 169 children with the common seizure disorders of generalized idiopathic epilepsy, generalized symptomatic epilepsy, temporal lobe epilepsy, frontal lobe epilepsy, central epilepsy, and non-localized partial epilepsy. They documented that across all epilepsy syndromes examined, age-normed FSIQ was below average. Bjornaes et al. (2001) found similar results in 17 children referred for evaluation and treatment of their seizures compared to controls.

Gülgöneng, Demirbilek, Korkmaz, Dervent, and Townes (2000) tested 21 children ages 6-14 with idiopathic occipital lobe epilepsy and compared their scores with those of normal controls and found that the group with epilepsy had significantly lower FSIQ scores. Pavone et al. (2001) also found lower intellectual functioning in children with generalized idiopathic epilepsy as compared to controls.

Sillanpää (1992) examined 143 Finnish children 4 to 15 years old with seizure disorders. He found that the most common comorbid diagnosis was mental retardation, defined as an overall FSIQ score below 70. In this study, nearly one-third (31.4%) of the children with seizures were mentally retarded.

Some researchers have investigated changes in intelligence over time in children with epilepsy. Bourgeois, Prensky, Palkes, Talent, and Busch (1983) and Ellenberg, Hirtz, and Nelson (1986) found that in patients who responded well to drug treatment,
there was no significant decline in intelligence over time. However, out of the original 72 children with epilepsy in the Bourgeois et al. study, a subgroup of 8 children demonstrated a decline in intelligence over time by at least 10 IQ points.

Further, Bjornaes et al. (2001) compared children’s FSIQ scores from two testing sessions approximately 42 months apart. They found that the FSIQ scores of children with epilepsy declined significantly over time (although somewhat anomalously, the FSIQ scores of adults with seizure disorders increased).

**Verbal Language**

Researchers have found mixed results concerning language abilities in children with epilepsy. Nolan et al. (2003) found that children with epilepsy obtained significantly worse standardized VIQ scores than their same age peers. Bjornaes et al. (2001) found similar results in 17 children with epilepsy. And Gülgönen et al. (2000) found that 21 children with idiopathic occipital lobe epilepsy performed significantly worse than their peers on measures of verbal abilities.

Schoenfeld et al. (1999) compared neuropsychological test performance in 57 children with complex partial seizures to 27 sibling controls. Results indicated that although the children with seizures performed significantly worse than the controls across all neuropsychological domains, expressive and receptive language abilities appeared to be the most vulnerable domain.

In contrast, Pavone et al. (2001) compared 16 children with absence epilepsy to 16 matched controls and found no significant differences between the two groups in verbal language abilities.

**Attention**
A majority of researchers have demonstrated an increased likelihood of attention problems in epilepsy (Bulteau, 2000; Sánchez-Carpintero & Neville, 2003; Powell et al., 1997; Sherman, Slick, Connolly, & Eyrl, 2007). This susceptibility, in some cases, may be due to the presence of non-epileptic seizures (Aldenkamp et al., 2000). Gülgönen et al. (2000) found that children with idiopathic occipital lobe epilepsy performed significantly worse than controls on measures of attention. Powell et al. (1997) reported that frontal epileptic disorders are generally characterized by complex attention impairments.

Sherman et al. (2007) examined attention using the parent report form of the ADHD Rating Scale, Fourth Edition (ARS-IV) in children with severe epilepsy. They found attention problems in 40% of their sample of 203 children. In this study, symptoms of inattention were more common than hyperactive/impulsive symptoms in the seizure disordered group.

However, not all researchers have found impaired attention in children with epilepsy. Oostrom, Schouten, Kruijswagen, Peters, and Jennckens-Schinkel (2002) compared the neuropsychological performance of 51 children recently diagnosed with idiopathic or cryptogenic epilepsy with that of 48 matched controls. They found that the children with epilepsy did not differ appreciably from the control group on measures of attention. Additionally, seizure type or frequency did not contribute to the variance.

The above research is concerning subclinical attention problems. Often, attention problems are severe enough to warrant a diagnosis of ADHD. See below for a thorough review of the comorbidity of epilepsy and ADHD.
Executive Functions

A number of researchers have found significantly worse performance on measures of executive function in children with epilepsy compared to children without seizures (Parrish et al., 2007). Hernandez et al. (2002) examined executive functions in children with frontal lobe, temporal lobe, and generalized epilepsy and found that, relative to controls, children with all types of epilepsy studied scored significantly lower on measures of response initiation and inhibition, mental flexibility, self-regulation of behavior, planning, and anticipation of actions.

Parrish et al. (2007) studied executive functioning in children with seizure disorders using the Delis-Kaplan Executive Function System (D-KEFS), a battery including nine subtests measuring a wide range of executive functions, and the Behavior Rating Inventory of Executive Function (BRIEF), a parent report measure. He compared performance on these measures in 53 children ages 8 to 18 who were recently diagnosed with epilepsy to test performance of 50 of their typically developing first cousins. Although the children with epilepsy demonstrated good seizure control, and most were taking only one antiepileptic medication, they performed significantly worse than controls on both measures of executive functioning.

Schoenfeld et al. (1999) found that children with complex partial seizures performed significantly worse than controls on the Trail Making Test, Form B, a measure used in the present study. D’Alessandro et al. (1990) supported these findings in 44 children with benign childhood epilepsy, who performed significantly worse on Form B of the Trail Making Test than 9 controls matched for FSIQ. However, when 11 of the original 44 children with epilepsy were tested after 4 years without seizures or EEG
abnormalities, their performance matched that of controls, suggesting that in this minority, initial impairment was likely a function of transitory cognitive impairment secondary to subclinical epileptiform discharges.

In contrast, Oostrom et al. (2002) found no differences in performance on both forms of the Trail Making Test between 51 children ages 7 to 16 years with epilepsy and 48 matched controls. However, these children were newly diagnosed with epilepsy, and several researchers have demonstrated that cognitive impairment is likely to increase over time in children with epilepsy.

Memory

Researchers report mixed results regarding memory performance in children with epilepsy. Gülgönen et al. (2000) found that children with idiopathic occipital lobe epilepsy performed appreciably worse than controls on measures of memory. Similarly, Schoenfeld et al. (1999) found significantly impaired immediate and delayed verbal and nonverbal memory as measured by the Wide Range Assessment of Memory and Learning (WRAML; used in the present study) and the children’s version of the California Verbal Learning Test (CVLT-C) in 57 children with complex partial seizures when compared to 27 sibling controls.

Pavone et al. (2001) documented significant deficits in visuospatial memory and delayed recall in 16 children with absence seizures as compared to 16 matched controls. However, these researchers found no impairment in verbal memory in the group with seizures.

Cheung, Chan, Chan, Lam, and Lam (2006) found no significant differences between 23 children and adolescents with preoperative temporal lobe epilepsy and
normal controls on the delayed recognition trials of the Rey-Osterrieth Complex Figure Test (ROCFT) and Hong Kong List Learning Test. These researchers did, however, find a negative correlation between length of time since epilepsy diagnosis and performance on delayed recognition trials of these measures.

**Visual Perception**

Researchers have demonstrated that children with epilepsy tend to perform poorly on measures of visual perception. Both Nolan et al. (2003) and Bjornaes et al. (2001) found children with epilepsy to demonstrate lower PIQ scores than their peers without seizures. Bulteau et al. (2000) found PIQ scores to be significantly lower than VIQ scores in 251 children with epilepsy.

Additionally, Pavone et al. (2001) found lower scores on measures of visuospatial abilities in children with absence seizures than in controls. And Gülönen et al. (2000) found that children with idiopathic occipital lobe epilepsy performed significantly worse than controls on nonverbal skill measures.

**Academic Achievement**

Several researchers have demonstrated that children with epilepsy tend to perform at statistically lower academic levels than peers (Aldenkamp, 2005). Besag (2002) proposed brain damage as the cause of both the epilepsy and learning problems, epilepsy as the primary cause of brain damage (which in turn causes learning disability), or epilepsy as the direct cause of the learning problems.

Most researchers examining academic achievement of children with epilepsy find 25 to 50% of them to be functioning below grade level (“Epilepsy Education,” 2003). Indeed, Sillanpää (1992) documented that 27.5% of 143 children with epilepsy either
received special education services or did not complete basic education. McDermott, Mani, and Krishnaswami (1995) reported that of 121 children with seizures, 28% had repeated a school grade.

Schoenfeld et al. (1999) found that children with complex partial seizures performed significantly worse than controls on the Spelling, Reading, and Math subtests from the Wide Range Achievement Test, Third Edition (WRAT-III), a widely used brief measure of academic achievement used in the current study.

Further, poor academic achievement appears to exist despite average intelligence. Among children with seizure disorders, research findings by both Holdsworth and Whitmore (1974) and Seidenberg et al. (1987) indicated lower academic achievement than their peers despite average intelligence.

Parent Report of Psychosocial Functioning

Researchers have demonstrated that children with epilepsy are more likely than their peers to have comorbid psychosocial diagnoses. In a large-scale, systemic, epidemiological study, Rutter, Graham, and Yule (1970) found children with seizure disorders to be 28.6% more likely to have a behavioral disorder than children without seizures. Even if not initially present at epilepsy onset, effects of treatment may provoke behavioral, developmental, familial, or psychiatric problems in children (Ziegler, Erba, Holden, & Dennison, 2000). Schoenfeld et al. (1999) reported a significant correlation between neuropsychological impairment and behavioral problems, suggesting a likelihood of impairment in both areas rather than only one.

Besag, O’Neill, and Ross (1999) examined behavior problems in children with epilepsy. They found that, according to a standardized parent report measure, 48% of the
children they investigated had behavior problems. This percentage is significantly higher than the 10% of children and adolescents with behavior problems typically found in the general population.

Schoenfeld et al. (1999) found that, relative to sibling controls, parents reported that their children with complex partial seizures exhibited significantly more behavior problems. Further, Hoare and Kerley (1991) documented that 54% of 108 children with epilepsy being seen at a specialist clinic exhibited psychiatric disturbance, as reported by a parent.

Lewis et al. (2000) reported different results, however, when looking at individuals with mental retardation. A group of 155 young Australian individuals with intellectual disability and epilepsy did not differ appreciably from controls in their rate of emotional or behavioral problems. The results suggest that individuals with epilepsy may be more likely to exhibit emotional or behavioral problems at higher intellectual ability levels.

Attention-Deficit/Hyperactivity Disorder (ADHD)

ADHD is a behavioral disorder characterized by symptoms of impulsivity and/or inattention. In order to meet the American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; 2000) criteria, individuals must exhibit at least six symptoms of inattention or hyperactivity-impulsivity causing clinically significant impairment in at least two settings before the age of seven.
ADHD is the most common behavioral disorder in children (Aldekamp, Arzimanoglou, Reijs, & Van Mil, 2006). Estimated prevalence rates vary widely and range from 8% to a difficult to believe high of 77% (Dunn, Austin, Harezlak, & Ambrosius, 2003). Faraone, Sergeant, Gillberg, and Biederman (2003) examined the prevalence rates of ADHD in 50 research studies from around the world. They found that in most studies, ADHD prevalence rates for children were between 5 and 10%. Also, the disorder occurs more commonly in boys than in girls, with ratios ranging from 4:1 to 9:1 (Barkley, 1997a).

Diagnostic assessment of ADHD has typically included administration of a parent report measure, such as the Conner’s Parent Rating Scales (CPRS), the Child Behavior Checklist (CBCL), or the ADHD Rating Scale, and a continuous performance test to provide a more objective measure of vigilance and impulse control. These two tools, along with a thorough review of family, developmental, and medical histories and measurement of intelligence and academic achievement, are generally considered to be the norm for diagnostic assessment. However, Monastra et al. (1999) found statistically elevated levels of cortical slowing in 482 individuals with ADHD using a simplified quantitative electroencephalography indicator, suggesting that this technique may also be a useful diagnostic tool to assess ADHD.

In a review of the literature, Daley (2006) noted that the etiology of ADHD includes both biological factors – genetics, brain structure, and their effect on neuropsychological function – and environmental explanations – parenting and diet. Researchers have identified familial trends and are currently working to locate specific genes associated with it. Biederman et al. (1995) found that severe marital discord, low
socioeconomic status, large family size, paternal criminality, maternal mental disorder, and foster care placement each significantly increased the risk of ADHD.

In addition to the etiology of the disorder, research on ADHD has assessed the neuropsychological and psychological functioning of children with the disorder. Expected functioning in children with ADHD will again be discussed in the following order of domains: General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, Academic Achievement, and Parent Report of Psychosocial Functioning.

*General Intelligence*

Most researchers have found that children with ADHD have lower FSIQ scores than their peers (Ek, Fernell, Westerlund, Holmberg, Olsson, & Gillberg, 2007). Indeed, Verté, Geurts, Roeyers, Oosterlaan, and Sergeant (2006) compared estimated FSIQ scores in 65 children with ADHD to those of 82 normal controls and found that the children with ADHD had significantly lower estimated FSIQ scores. Similarly, Tripp, Ryan, and Peace (2002) found that 28 children with ADHD attained appreciably lower (>20 standard score units) FSIQ scores on the Australian adaptation of the WISC-III than an equal number of normal controls.

Lahey et al. (1998) also found appreciably lower FSIQ scores in 82 children with the Combined subtype and 13 children with the Inattentive subtype of ADHD compared to 126 children without ADHD. However, children with the Hyperactive/Impulsive subtype of the disorder did not differ significantly from the control group on FSIQ scores.

Not all researchers, however, have found impaired FSIQ scores in children with ADHD. Semrud-Clikeman, Guy, Griffin, and Hynd (2000) found no significant
differences in intelligence scores between 32 children with ADHD and 71 controls. Schuck and Crinella (2005) argued that intelligence and executive functions are independent dimensions and that what might appear to be impaired intellectual functioning in children with ADHD is actually impaired executive functioning. They investigated intellectual and executive functioning in 123 boys with ADHD and found that the g factor loaded heavily on verbal measures and was relatively independent of measures of executive functioning and performance on most subtests of the WISC-III.

**Verbal Language**

Verbal impairment in children with ADHD has been extensively documented. However, it is unclear whether impaired language abilities in children with ADHD are the result of failure to adequately attend to the social and educational environment because of impaired attention or of global neuropsychological impairment often found in the disorder.

Bruce, Themlund, and Nettelbladt (2006) found that parents reported problems in language comprehension three times more frequently than expressive language problems in their children with ADHD. In their study, language abilities were found to be as impaired as attention, social skills, and arithmetic.

Semrud-Clikeman et al. (2000) looked at rapid naming using the Boston Naming Test (BNT), a measure of confrontational naming also used in the current study. There were no significant differences between the scores of 32 children with ADHD and 71 controls. Consistent with this finding, compared to children with reading disorders, Felton, Wood, Brown, Campbell, and Harter (1987) found that children with ADHD performed significantly better on a measure of confrontational naming.
Andreou, Agapitou, and Karapetsas (2005) examined verbal skills in 69 children with ADHD and compared them to those of controls matched for age and gender. The ADHD group performed appreciably worse than the control group on all of the WISC-III subtests contributing to the VIQ score: Vocabulary, Similarities, Arithmetic, Digit Span, Information, and Comprehension.

Impaired performance compared to controls on the Vocabulary subtest, a measure of knowledge of and ability to express word definitions, indicates underdeveloped language development. The authors indicated that poorer performance on the Similarities subtest, a measure of verbal concept formation, may suggest decreased proficiency in organization of speech.

It is not surprising that the ADHD group performed worse than controls on the Arithmetic and Digit Span subtests because although these are verbal measures, they also demand focused attention and concentration. Relatively poor verbal explanation and social judgment as found in poorer performance on the Comprehension subtest is also not unexpected, because of similar findings regarding verbal abilities and social judgment.

Needless to say, in the Andreou (2005) study, the Verbal Comprehension Index (VCI), Freedom From Distractibility Index (FFD), and VIQ score were also significantly lower in the ADHD group than the control group. Tripp et al. (2002) found similar results: their ADHD group obtained significantly lower VIQ scores than typically developing peers.

However, not all findings support impaired verbal abilities in children with ADHD. Pineda et al. (1999) found no significant difference between performance of 100 boys with ADHD and 72 normal controls on the Vocabulary subtest of the WISC-R. Ek
et al. (2007) reported that, of a cognitive battery given to children with ADHD, the highest scores were in verbal comprehension.

Attention

Given the very definition of the disorder, it is not surprising that attention deficits have been well-documented in children with ADHD. Kılıç, Şener, Koçkar, and Karakaş (2007) found that 40 children with the Combined subtype of ADHD performed significantly worse than controls on measures of selective attention, sustained attention, and short-term memory.

Pineda et al. (1999) examined attention in boys with ADHD using several different measures including a cancellation task, a reaction time task, and the Digit Span, Digit/Symbol Coding, Arithmetic, and Mental Control subtests from the Wechsler scales. Results indicated impaired performance across all attention measures in the ADHD group compared to typically developing controls.

Calhoun and Mayes (2005) reported that, on the WISC-III, children with ADHD scored appreciably lower than controls on the Freedom from Distractibility Index (FDI) and the Processing Speed Index (PSI) than on the Verbal Comprehension Index (VCI) and the Perceptual Organization Index (POI). The FDI and the PSI are fittingly named indexes that one would expect children with attention problems to perform more poorly on than their peers without attention problems.

Drechsler, Brandeis, Földényi, Imhof, and Steinhausen (2005) reported that, compared to controls, children with ADHD performed significantly worse on a measure of short term attention and concentration, the Digit Span subtest from the Wechsler
Intelligence Scales for Children, Revised (WISC-R). These results persisted over three testing sessions with a mean interval of 2.6 years between them.

Kaplan, Dewey, Crawford, and Fisher (1998) found that in a sample of 53 children with ADHD and 112 controls, the children with ADHD performed significantly worse than the controls on the Number/Letter Memory, Sentence Memory, and Finger Windows subtests of the WRAML, measures of immediate memory requiring attention and concentration.

**Executive Functions**

Impairments in all areas of executive functioning have been well-established in ADHD populations (Barkley, 1997b; Marks et al., 2005; Wilding, 2005). Indeed, many investigators view the disorder as primarily an executive dysfunction problem. Given the important role of the frontal lobes in both attention and executive functioning, and findings that stimulant medication, historically used to treat ADHD, has helped with executive functioning, this is not surprising (Kempton, Vance, Maruff, Luk, Costin, & Pantelis, 1999; Swanson, 2003). Executive function deficits common in ADHD include poor planning, impaired impulse control, difficulty sustaining goal-directed behavior, poor self-monitoring and self-regulation, and inability to delay gratification (Lezak, Howieson, & Loring, 2004; Murphy, Barkley, & Bush, 2001).

Geurts, Verté, Oosterlaan, Roeyers, and Sergeant (2004) investigated executive functions in children with ADHD and found specific deficits in inhibition and verbal fluency tasks. The authors noted that although these results are significant, they are not supportive of the model presented by Barkley (1997b) that claims children with ADHD demonstrate deficits in all areas of executive functioning.
Tripp et al. (2002) also examined executive functioning in children with ADHD. The 28 children in the group with ADHD performed significantly worse than 28 typically developing controls on a wide array of executive function measures. Performance was characterized particularly by impaired mental flexibility and working memory, and an increased rate of errors and perseverative responses compared to controls. However, most of these differences disappeared when FSIQ scores were controlled for (and were perhaps a result of lower overall intellectual function).

Pineda, Ardilla, Rosselli, Cadavid, Mancheno, and Mejia (1998) examined performance on 3 measures of executive function in 62 boys with ADHD and 62 controls. The boys with ADHD performed significantly worse on all three measures. More recently, Pineda et al. (1999) reported that boys with ADHD performed appreciably worse than controls on the Mazes subtest from the Wechsler scales. This measure of planning and rule following was also used in the present study.

Impaired executive functioning appears to persist into adolescence. Murphy et al. (2001) compared executive function scores in a group of 105 older adolescents and young adults with ADHD to those of 64 matched, normal controls. They found impaired performance in the ADHD group on measures of response inhibition, sustained attention, interference control, and verbal and nonverbal working memory compared to the control group. These results were independent of ADHD subtype. In fact, there were no significant differences in executive functioning between ADHD subtypes. However, Verté et al. (2006) found that inhibitory control in children with ADHD did not differ significantly from that in normal controls.
Memory

Most current research on memory performance in children with ADHD suggests that there is impairment in this area. However, many of these studies include the caveat that attention and associated executive functions play a large role in encoding of information. Therefore, it is important to consider whether impaired memory performance on neuropsychological measures is due to impaired initial learning as opposed to an intrinsic impairment in memory.

Barnett, Maruff, and Vance (2005) found that both ADHD children who were medication naïve and those treated with medication performed significantly worse on a measure of visuospatial memory than controls. However, the authors noted that the poorer performance may have been a result not of an actual memory deficit, but of failure to initially encode the information because of attention problems. Evidence for this hypothesis includes consistent (though impaired) performance on the immediate recall trial and over a number of delay trials.

Kaplan et al. (1998) examined savings scores (delayed recall trial divided by immediate recall trial) in 53 children with ADHD using the WRAML and found that they performed as well as 112 controls on material presented once (Story Memory subtest). Initially impaired learning was evident in the ADHD group, likely due to impaired attention, but the children were able to recall comparable percentages of the information initially learned, indicating impaired encoding with material presented once, but intact memory. On information presented four times (Sound Symbol, Verbal Memory, and Visual Memory subtests), savings scores in the ADHD group were like those of the
control group, indicating intact learning and memory over trials. These results do not support differences between visual and verbal memory in children with ADHD.

In accordance with the above results, Pineda et al. (1999) examined memory performance in boys with ADHD and found that it took significantly more trials to obtain maximum verbal learning than controls, but that once acquired, memory performance was similar to that of controls. In this study, visual memory performance was impaired compared to controls, although it is unclear whether there were learning trials on the measure used. If the measure included only one presentation of the visual stimulus, it is likely that impaired encoding secondary to attention problems was responsible for impaired memory scores.

**Visual Perception**

Surprisingly little research has focused on visual perception abilities in children. What findings there are appear to be inconsistent. Nevertheless, Tripp et al. (2002) found that 28 children with ADHD attained significantly lower PIQ scores than 28 normal controls.

Pineda et al. (1999) found that boys with ADHD performed significantly worse than controls on the Block Design subtest from the Wechsler scales, a widely used measure of visuospatial integration skills, and on the copy trial of the Rey-Osterrieth Complex Figure Test (ROCFT), a measure of visuospatial perception and construction.

Shin, Kim, Cho, and Kim (2003) studied the copy trial of the Rey-Osterrieth Complex Figure (ROCFT), a measure of visuospatial perception and construction, in Korean children with ADHD. Compared to controls (and children with learning disorders and Tic Disorder), the children with ADHD performed significantly worse overall
copying the figure. They also failed to demonstrate the trend towards better organization with increasing age that was found in the control group and in studies of American children.

However, Nydén, Billstedt, Hjelmquist, and Gillberg (2001) found different results when comparing children with ADHD to children with Asperger’s Disorder and Learning Disorder. The ADHD group achieved significantly higher PIQ scores compared to children with the other diagnoses. The ADHD group also performed significantly better than the Asperger’s Disorder and Learning Disorder groups on the WISC Perceptual Organization Index, a cluster score reflecting visuospatial reasoning abilities.

**Academic Achievement**

Poor academic achievement is relatively common in ADHD (Biederman, 2000), owing at least in part to the increased risk of comorbid learning disorders in the population. In the first meta-analysis of academic achievement in ADHD, Frazier, Youngstrom, Glutting, and Watkins (2007) found a moderate to large discrepancy in academic achievement between children with ADHD and controls, with the ADHD group scoring significantly below controls. They found the largest effect sizes on standardized reading achievement measures, although moderate to large effect sizes were also found in rating scales and objective measures such as G.P.A. and repeated grades. Academic achievement relative to peers decreased with age, likely due to the typical decrease in ADHD symptoms over time.

Barnett et al. (2005) found that children with ADHD performed appreciably worse on the Spelling and Arithmetic subtests of the third edition of the Wide Range
Achievement Test (WRAT-III) than healthy controls. This finding was consistent for both the medicated and non-medicated ADHD groups.

Lahey et al. (1998) compared achievement scores in 126 children with ADHD to those of 126 typically developing controls. Mathematics achievement was significantly lower than controls in the children with Combined or Inattentive ADHD. However, although the group with the Hyperactive/Impulsive subtype of ADHD performed worse on the measure of mathematics achievement, this difference was not significant. There were no significant differences between the ADHD and control groups in reading achievement scores. Semrud-Clikeman et al. (2000) also found no differences between reading achievement scores in children with and without ADHD.

Parent Report of Psychosocial Functioning

Impairment in school or social function is a requirement for the diagnosis of ADHD. According to the diagnostic criteria from the DSM-IV-TR (2000), in the Combined subtype, the child with ADHD often interrupts or intrudes on others and has difficulty waiting for his or her turn. These symptoms are in and of themselves indicative of impaired psychosocial functioning. Biederman (2000) noted that children with ADHD are at high risk for academic underachievement, poor social relationships, family conflict, delinquency, smoking, and substance abuse. It should come as no surprise, then, that behavior problems are common in ADHD, leading to parent reports of difficulties in psychosocial functioning.

Tripp, Schaughency, and Clarke (2006) examined parent report of behavioral problems in their children with ADHD using the Conners Parent Rating Scales (CPRS), used in the present study, and the Child Behavior Checklist (CBCL) and compared them
to controls. Significantly more children in the ADHD, Combined Type group than controls met criteria for behavioral disorders according to their parents' ratings than controls.

Verté et al. (2006) reported that children with ADHD were rated by their parents and teachers as significantly more hyperactive/impulsive, oppositional, conduct disordered, and inattentive than children without ADHD.

Barnett et al. (2005) examined behavioral problems in children with ADHD using the parent form from the Abbreviated Conners Parent Rating Scale (ACRS) and the parent and teacher forms from the Child Behavior Checklist (CBCL). The children with ADHD were rated as having appreciably more behavior problems than controls.

Lahey et al. (1998) found that teachers rated children with ADHD in their classrooms as liked by fewer classmates, ignored by more classmates, more disruptive, and less self-controlled than their peers without ADHD.

Comparability of the Neuropsychology of Epilepsy and ADHD

In summary, the above literature review reveals strong overlaps in the neuropsychological profiles of epilepsy and ADHD in children. Children with either disorder are more likely than their typically developing peers to demonstrate impaired performance on measures of overall intelligence, verbal language, attention, executive functioning, visual perception, academic achievement, and parent report of psychosocial functioning.

Attention and executive functioning appear to be particularly vulnerable to impairment in each of these disorders. Indeed, attention and executive functioning
weaknesses tend to be particularly sensitive to all types of brain differences and damage. Given their critical role in all other cognitive and behavioral domains, this review of literature supporting global impairment in many children with epilepsy and ADHD is not unexpected, nor is the high comorbidity of the disorders.

Comorbidity of Epilepsy and ADHD

Children with seizure disorders are at higher risk for cognitive impairments and appear to be especially vulnerable to attention problems (Sánchez-Carpintero & Neville, 2003). Several researchers have demonstrated that children with epilepsy are much more likely to have ADHD than children without seizures (van der Feltz-Cornelis & Aldenkamp, 2006). Mulas, Tellez de Meneses, Hernandez-Muela, Mattos, and Pitarch (2004) report that ADHD is the most frequent comorbid diagnosis seen in their epilepsy clinic.

Given that epilepsy is the most common neurological in children, and ADHD is the most common behavioral disorder in children, high rates of comorbidity should come as no surprise. Children with epilepsy are three to five times more likely to meet criteria for ADHD than children without seizures (Schubert, 2005). Barkley (1990) reports that the prevalence of ADHD is 3 to 5% in otherwise healthy children, but 20% in children with epilepsy. Rutter et al. (1970) reported that 12% of his sample of children with epilepsy also met criteria for ADHD. And in their sample of 175 children with epilepsy, Dunn et al. (2003) found a prevalence rate of ADHD of 38%.

It appears as though the likelihood of ADHD co-occurring with seizure disorders increases with the severity of the epilepsy. Sherman et al. (2007) found that a full 60% of
their sample of 203 children with severe epilepsy also met criteria for ADHD. In addition, these researchers noted that the Inattentive subtype of ADHD was much more common in their sample of seizure disordered children than in the general population.

Given the high rate of comorbidity, some have argued that ADHD should not be a separate diagnosis in the context of an epilepsy syndrome. Indeed, a number of researchers have demonstrated overlaps of electroencephalogram (EEG) abnormalities in children with epilepsy and ADHD (Sherman, Armitage, Connolly, Wambera, & Strauss, 2000). Others have postulated that attention problems may be expected secondary effects of seizure disorders and their treatment, and not intrinsically diagnosable separately (Aldenkamp et al., 2006; Koop, 2003).

However, Powell et al. (1997) noted that, unlike mood disorders with exclusionary criteria for disorders secondary to general medical conditions, current diagnostic options for ADHD do not include ADHD secondary to a general medical condition. That is, at present, a diagnosis of ADHD is made regardless of neuropathology. The failure to account for specific neurological disorders that may better account for the presenting symptoms represents a shortcoming in the diagnostic criteria.

The underlying mechanisms producing ADHD in the context of epilepsy are largely unknown (Sherman et al., 2007). Potential reasons for the comorbidity of ADHD and epilepsy include the epilepsy itself, epilepsy treatment or its side effects, reactions to the epilepsy, associated brain damage or dysfunction, and the causes that also apply to children without seizure disorders (Besag, 2002). Put another way, Aldenkamp et al. (2006) explain that ADHD may predate the epilepsy and increase a child's vulnerability
to seizures, or, conversely, that the epilepsy may predate the ADHD and increase the vulnerability for ADHD characteristics to develop.

Because epilepsy syndromes and ADHD frequently co-occur, providers working with children with seizures should pay attention to potential indications of attention problems in their patients (Pellock, 2004). Mulas et al. (2001) go so far as to recommend EEG's for patients presenting with inattention. Additionally, providers should consider attention problems when providing epilepsy treatment. ADHD and epilepsy comorbidity may affect the epilepsy and its treatment, and conversely, the comorbidity may affect the ADHD and its treatment. Despite the concerns of some investigators (Pellock, 2004), however, stimulants and antidepressants have generally been found to be safe and effective in children with epilepsy (Aldenkamp et al., 2006; Mulas et al., 2004; Ziegler et al., 2000), and most antiepileptic medications have been found to be safe and effective in children with ADHD (Pellock, 2004).
METHODS

Sample and Procedure

Test scores from 427 screening batteries of neuropsychological tests administered to child and adolescent patients ages 6 to 17 were gathered from the archives of a psychologist’s private practice in McMinnville, Oregon. Data on children younger than 6 were not included in this analysis in order to develop the most consistent sample possible; most neuropsychological measures used with this study’s clinical sample are not standardized for children 6 and under (Hartlage & Telzrow, 1986), including the WISC-III (Wechsler, 1991). Similarly, 17 years was chosen as the upper age cutoff because adult measures are typically given to individuals ages 18 years and older.

Approximately 90% of these young patients were referred for assessment by a pediatric neurologist practicing in Portland, Oregon, and therefore came from an urban population. The remaining 10% of clients were referred from both rural and urban populations by other pediatric neurologists, school psychologists, general practice pediatricians, and parole officers. Typical referral questions for this population related to possible diagnoses of ADHD, Cognitive Disorder, Learning Disorder, Mood Disorder, Autism Spectrum Disorders, Pervasive Developmental Disorder, behavior problems, and potential cognitive effects of epilepsy.

Each child or adolescent participated in approximately four hours of testing in a quiet office. Assessment measures covered verbal, visuospatial, attention, executive function, memory, achievement, and behavior/personality domains. All tests were
administered in a standardized fashion, and all test results were transformed into standard scores (with a mean of 100 and a standard deviation of 15) using the best available normative data.

Children were included in the epilepsy group if they carried a documented, current diagnosis of an epilepsy syndrome by a pediatric neurologist. The majority of these children and adolescents underwent video-EEG monitoring for diagnostic clarification. All types of epilepsy syndromes (e.g., partial, focal, and generalized) were included in the group.

In most cases, ADHD diagnoses were made or supported by either the pediatric neurologist, the psychologist in private practice with a specialty in child and adolescent assessment, or both. To be included in the ADHD group, the children had to have a documented diagnosis of ADHD made by a psychologist or pediatric neurologist. All subtypes of ADHD were included in the group.

To ensure confidentiality, no personal health information left the private practice location. Client names, health record numbers, and dates of birth were kept securely, in a locked cabinet in a locked room at the private practice.

Research ethics approval was granted by the Institutional Review Board of Pacific University prior to data collection. Because the data was archival and not attached to identifying information, no informed consent was necessary.

Instruments

Neuropsychological tests were organized into clusters to create robust domain of neuropsychological function measures. Clusters included General Intelligence, Verbal
Language, Attention, Executive Functions, Memory, Visual Perception, Academic Achievement, and Parent Report of Psychosocial Functioning. A description of these clusters and the instruments on which they are based follows.

General Intelligence

The General Intelligence Cluster or measure of overall cognitive functioning was, when available, a derived Full Scale Intelligence Quotient (FSIQ) score from the Wechsler Abbreviated Scales of Intelligence (WASI). The WASI norming sample included 2,245 individuals aged 6 to 89 years. Ratios of gender, race/ethnicity, and geographical region were representative of 1997 United States Census data. Split-half reliability for child scores on all four subtests comprising the scales (Vocabulary, Block Design, Similarities, and Matrix Reasoning) ranged from 0.81 to 0.97. Construct validity and correlations with other achievement measures were good (The Psychological Corporation, 1999).

Less frequently, General Intelligence Cluster scores were derived FSIQ scores from relevant subtests from the third edition of the Wechsler Intelligence Scales for Children (WISC-III). The Wechsler scales are the most consistently used measures of cognitive functioning, and they are also highly reliable (Spreen & Strauss, 1998).

When a derived General Intelligence score was not available, an FSIQ score was estimated based upon Vocabulary and Block Design subtest scores administered from one of the above measures using the WASI norms. Derived scores combining both are widely used as brief measures of intelligence.

The Vocabulary subtest is a measure of expressive knowledge of word definitions. Patients are asked to provide definitions for up to 38 words presented aurally.
and visually. Two points are awarded for superior responses, one point for concrete, overly general, or vague responses. The examiner queries responses that are vague but potentially indicative of a higher level answer. The measure is discontinued after 4 consecutive failures (The Psychological Corporation, 1999).

Block Design measures visual-spatial motor problem solving in the assembly of two-dimensional designs with blocks. At start, the examinee is asked to copy a design or designs made by the examiner, and as the test progresses through its 13 items, the examinee copies designs presented in the stimulus booklet. The number of blocks increases from four to nine towards the end of the subtest. Bonus points are awarded for speedy performance, and there is a time limit for each item. The measure is discontinued after two consecutive errors (The Psychological Corporation, 1999).

*Verbal Language*

The Verbal Language Cluster was comprised of the Similarities subtest from the Wechsler scales, the Boston Naming Test (BNT), and the Peabody Picture Vocabulary Test, Third Edition (PPVT-III). The Similarities subtest is a measure of verbal abstract reasoning and concept comprehension. On the first 4 items, the patient is asked to match pictures. On items 5 through 26, the children are asked to describe the similarity between two orally presented word pairs, e.g., "In what way are an orange and a banana alike?" Responses reflecting abstract relationships are awarded two points, concrete responses receive one point, and "don’t know" or incorrect responses receive no credit. The measure is discontinued after four incorrect responses. Lezak et al. (2004) noted that the Similarities subtest tends to load at least moderately on the verbal factor. Test-retest correlations range from 0.83 to 0.88 (The Psychological Corporation, 1999).
The BNT is a measure of object naming in which clients are shown 60 line drawings and asked to name each object. With children under ten, the examiner begins with the first item. Item 30 is the starting point with older children. The examinee must correctly name eight objects before the examiner proceeds further. When patients cannot initially name an item, the examiner provides a semantic cue. If the semantic cue does not help, a phonetic cue is then given. The test is discontinued after six successive incorrect items (Kaplan, Goodglass, & Weintraub, 1976).

The BNT has solid psychometric properties. Halperin, Healy, Zeitchik, Ludman, and Weinstein (1989) investigated the construct validity of the BNT and found that the measure loaded highly on a word knowledge factor. Sawrie, Chelune, Naugle, and Luders, (1996) found a test-retest reliability of 0.94.

The last measure comprising the Verbal Language cluster was the PPVT-III, a measure of one-word receptive vocabulary that does not require expressive language abilities. The patient points to one of four pictures that represents the stimulus word, as shown by the examiner. The examinee must achieve six correct in order to continue forward with the test, and the test is discontinued after six of eight incorrect responses. Standardization of the third edition involved a population-based sample of 2,725 individuals (Dunn & Dunn, 1997). Dunn and Dunn (1997) found a split-half reliability of 0.94 and a positive correlation with VIQ scores.

Attention

The Attention Cluster included the Digit Span, Symbol Search, and Digit-Symbol Coding subtests from the WISC-III. Digit Span is the most widely used measure of short term auditory-verbal memory (Lezak, Howieson, & Loring, 2004). This test consists of
two parts, Digits Forward and Digits Backward. In both parts, the examiner reads up to seven pairs of random number strings, and the patient is to either repeat exactly what he or she heard or reverse the sequence of the numbers, depending on which half of the test is being administered. The examiner discontinues the measure after the client fails both trials of a given number string length or after successful completion of the measure. The authors of the WISC-III found an average split-half reliability coefficient of 0.85 and test-retest reliability of 0.73 across all applicable ages (Wechsler, 1991).

The Symbol Search subtest is a measure of attention requiring speed and accuracy. The child’s task is to decide if target symbols appear in the rows of symbols next to them. The patient is to mark the “yes” box if the target symbol is in the corresponding row or the “no” box if it is not. The child is given 120 seconds to correctly complete as many items as he or she can. Incorrect items are subtracted from the number of correct items to derive a raw score, which is converted to a scaled score. The measure demonstrates good split-half reliability at 0.76 and test-retest reliability at 0.74 (Wechsler, 1991).

The Digit-Symbol Coding subtest is a measure of complex attention and information processing. This paper-and-pencil task is composed of rows of random numbers from one to nine above empty boxes. At the top of the page is a key matching each number to a symbol. The examinee has two minutes to fill in as many of the empty boxes as possible with the corresponding symbol. Skipping ahead is not permitted. The standard score is derived from the number of correct items. The authors of the WISC-III found a split-half reliability coefficient of 0.79 and a test-retest reliability of 0.77 (Wechsler, 1991).
The WISC-III, the battery from which the Digit Span, Symbol Search, and Digit-Symbol Coding subtests were drawn, is the most widely used measure of cognitive abilities in children. The standardization sample of the battery included 2200 children ranging in age from 6 years to 16 years, 11 months. There were 100 boys and 100 girls in each of the 11 age groups. Proportions of races and ethnicities represented in the normative group were based upon 1988 United Stated Census data. The United States was divided into four geographical regions from which a representative number of children’s test scores were used for standardization (Wechsler, 1991).

Researchers have demonstrated that the WISC-III has good psychometric properties. The battery demonstrates adequate to excellent overall test-retest and split-half reliability of its subtests, ranging from 0.57 to 0.95. Concurrent validity findings are moderate to excellent, ranging from a 0.65 correlation with the Woodcock-Johnson Psycho-Educational Battery, Revised (WJ-R) to a 0.96 correlation with the Wechsler Adult Intelligence Scales, Revised (WAIS-R). Predictive validity coefficients using the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) and WAIS-R were excellent in the mid-0.80’s to mid-0.90’s (Wechsler, 1991).

Executive Functions

The Executive Function Cluster was comprised of the Mazes subtest from the WISC-III, the Trail Making Test, Form B (Trails B), and the Matrix Reasoning subtest from the WASI. The Mazes subtest is a measure of the executive functions of planning (by way of route finding) and resistance of impulsivity in which the child is to draw a line from a starting point to the end goal without entering dead ends, drawing through existing lines, or lifting the pencil. Test items increase in difficulty, and the measure is
discontinued after two successive failures. Researchers demonstrated good to excellent concurrent and predictive validity of the subtest. The measure’s split-half reliability coefficient is 0.70, and its corrected test-retest reliability coefficient averaged for ages 6 to 16 is 0.57 (Wechsler, 1991).

Trail B is the second, more challenging, trial of the Trail Making Test (TMT). It is a paper-and-pencil measure of divided attention in which the examinee is required to switch between sequencing numbers and letters in order, i.e., 1, A, 2, B, etc.. The examiner instructs the patient to connect the numbers and letters as quickly as possible without making errors or lifting the pencil from the page. The test requires the executive function ability of shifting between sets. The number of seconds it takes an individual to complete the measure is compared to performance by normal controls to derive a standard score. Spreen and Strauss (1998) reported that most reliability coefficients for the TMT are in the 0.80’s and 0.90’s. Lezak et al. (2004) asserted that the measure is sensitive to cognitive impairment.

In the Matrix Reasoning subtest from the WASI, the examiner presents the examinee with incomplete gridded patterns. The examinee must then choose the correct response from five possible options to complete the grid. This untimed measure of conceptual reorganization is discontinued after four consecutive incorrect responses or four errors on five consecutive problems. Construct validity and test-retest and split-half reliability are moderate to excellent (The Psychological Corporation, 1999).
Memory

The Memory Cluster was comprised of the Story Memory and Sentence Memory subtests from the Wide Range Assessment of Memory and Learning (WRAML) and the delayed recall trial of the Rey-Osterrieth Complex Figure Test (ROCFT).

The WRAML, the test battery from which the Story Memory and Sentence Memory subtests were drawn, was normed and standardized using test scores from 2,363 children aged 5 to 16. Gender, geographic region, and parent occupation were representative of the United States population (Sheslow and Adams, 1990).

The Story Memory subtest from the WRAML is a measure of auditory-verbal memory in which the child is asked to recall as many details from two stories read aloud by the examiner as she or he can. Reliability coefficients range between 0.80 and 0.85, and the measure is well-validated (Sheslow and Adams, 1990).

The Sentence Memory subtest from the WRAML is another measure of auditory-verbal memory. The examiner reads sentences aloud and asks that the child repeat them. The sentences increase in length, and the measure is discontinued after three consecutive errors. Internal consistency and reliability are excellent (Sheslow and Adams, 1990).

The delayed recall trial of the ROCFT is a measure of memory for complex visual information. During the initial copy trial, the child is provided with a blank sheet of paper and instructed to copy a complex figure as accurately as possible. The stimulus picture is removed before the subsequent immediate recall trial. After 20 to 30 minutes, the child is again asked to draw as much of the initial figure as he or she can remember. The psychologist in private practice scored these recalled figures using the Meyers and Meyers (1995) scoring criteria. Derived standard scores from this delayed trial were used

**Visual Perception**

The Visual Perception Cluster included the Benton Judgment of Line Orientation Test (JLO) and the Hooper Visual Organization Test (HVOT). The JLO is a measure of visuospatial judgment initially developed by Benton, Hannay, and Varney. The measure comes in a booklet consisting of 5 practice items and 30 test items. In administering the test, the examinee instructs the child to match a pair of angled lines to one line in a display of 11 lines of varying orientation. The items increase in difficulty over trials (Benton, deS. Hamsher, Verney, & Spreen, 1983).

Researchers have demonstrated solid psychometric properties for the JLO. Qualls, Bliwise, and Stringer (2000) found internal consistency of the measure to be 0.90. Correlated split-half reliability for Forms H and V were found to be 0.94 and 0.89, respectively (Benton, deS. Hamsher, Verney, & Spreen, 1983).

The HVOT is a 30-item measure of visual integration consisting of disconnected, visually jumbled parts of everyday objects that the examinee is to mentally rearrange into pictures and name (Spreen & Strauss, 1991). One point is given for correct identification of the object, and a few of the items have half point responses. The total score is the total of these points, which is converted into a standard score.

The HVOT is a sensitive measure of cognitive impairment and has a test-retest reliability of 0.86 after 6 and 12 months (Lezak, 1982). Seidel (1994) found that the
measure loads heavily on a factor shared with performance subtests from the WISC: Block Design, Picture Arrangement, Object Assembly, and Picture Completion.

*Academic Achievement*

The Academic Achievement Cluster was composed of the Wide Range Achievement Test, Third Edition (WRAT-III), a brief screening measure of academic achievement. This measure was normed on test scores from approximately 5000 individuals ages 5 to 75 years. Reliability coefficients range from 0.82 to 0.95. The test correlates highly with FSIQ scores from the WAIS-R and WISC-R (Wilkinson, 1993). The achievement test is composed of three subtests: Reading, Spelling, and Arithmetic.

The Reading subtest is comprised of a list of 15 letters that the child is to name and 75 words that increase in difficulty that the child is to read aloud. It is a measure of single word identification and not comprehension. The examinee is allowed 10 seconds to respond, and the test is discontinued after 10 consecutive errors. The sum of words correctly pronounced is transformed into a standard score and grade equivalent. In the present study, only the standard score was used.

On the Spelling subtest, the examiner has the child write his or her name and then dictates letters and words of increasing difficulty that the child is to write on the response sheet using the correct spelling. The child must correctly spell five successive words in order to continue with the task, and the measure is discontinued after 10 consecutive errors.

The Arithmetic subtest is a measure of calculation ability that begins with having the child count, read number symbols, and solve oral arithmetic problems. The child is
then provided with 15 minutes to complete written computations of increasing difficulty.

The total correct score is converted to a standard score.

*Parent Report of Psychosocial Functioning Cluster*

The Parent Report of Psychosocial Functioning Cluster included the following three scales from the Conners' Parent Rating Scales, Revised (CPRS-R): DSM-IV Total, ADHD Index, and Conners' Global Index. The Conners' Scales are the most widely used behavioral scales to measure attention problems in children (Pineda et al., 1999). Each child patient's parent completed the 80-item paper-and-pencil measure regarding their child's behavior. The scales were normed using scores from over 8000 children and adolescents of a variety of races and ethnicities, although the authors do not specify from what population or socioeconomic status the sample was drawn. Test-retest reliability coefficients ranged from 0.47 to 0.85. Criterion validity was found to be acceptable (Multi Health Systems, 2000).

The DSM-IV Total scale consists of 18 items drawn directly from the DSM-IV criteria for ADHD (Gianaris, Golden, & Greene, 2001). Two subscales make up this scale, the DSM-IV Inattentive and DSM-IV Hyperactive-Impulsive, and are designed to distinguish between ADHD subtypes. Zelko (1991) examined the discriminant validity of the Hyperactive-Impulsive subscale in a sample of 89 boys. He found that children with ADHD were rated as appreciably higher on the Hyperactive-Impulsive subscale by their parents or caregivers than psychiatric controls or normal controls.

The ADHD Index is made up of 12 items that best differentiate children with ADHD from children without the disorder (Multi Health Systems, 2000). The Conners' Global Index is a measure of overall functioning that is sensitive to treatment outcome.
This 10-item index is composed of the Restless/Impulsive and Emotional Lability subscales, which were empirically derived.

Statistical Analysis

*Group Differences*

Data was analyzed using SPSS, version 14.0. Demographic variables (age and gender) of the three groups (Epilepsy, ADHD, and Epilepsy and ADHD) were separately submitted to analyses of variance (ANOVA) to determine whether the demographical groups differed from each other.

*Discriminant Analyses*

The three groups (Epilepsy, ADHD, and Epilepsy and ADHD) were compared on the eight clustered variables (General Intelligence, Verbal Language, Attention, Executive Functioning, Memory, Visual Perception, Academic Achievement, and Parent Report of Psychosocial Functioning), each consisting of combined standard scores on subtests or subscales. Table 1 presents measures by cluster.
TABLE 1. Neuropsychological measures by cluster

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Intelligence</td>
<td>Wechsler Abbreviated Scales of Intelligence (WASI)</td>
</tr>
<tr>
<td>Verbal Language</td>
<td>Boston Naming Test (BNT)</td>
</tr>
<tr>
<td></td>
<td>Peabody Picture Vocabulary Test (PPVT-III)</td>
</tr>
<tr>
<td></td>
<td>Wechsler Intelligence Scale for Children (WISC-III)</td>
</tr>
<tr>
<td></td>
<td>Similarities</td>
</tr>
<tr>
<td>Attention</td>
<td>WISC-III Coding</td>
</tr>
<tr>
<td></td>
<td>WISC-III Symbol Search</td>
</tr>
<tr>
<td></td>
<td>WISC-III Digit Span</td>
</tr>
<tr>
<td>Executive Functions</td>
<td>Trail Making Test, Form B (Trails B)</td>
</tr>
<tr>
<td></td>
<td>WISC-III Mazes</td>
</tr>
<tr>
<td>Memory</td>
<td>WRAML Sentence Memory</td>
</tr>
<tr>
<td></td>
<td>WRAML Story Memory</td>
</tr>
<tr>
<td></td>
<td>Rey-Osterrieth Complex Figure Test (ROCFT), Delay Trial</td>
</tr>
<tr>
<td>Visual Perception</td>
<td>Judgment of Line Orientation Test (JLO)</td>
</tr>
<tr>
<td></td>
<td>Hooper Visual Organization Test (HVOT)</td>
</tr>
<tr>
<td>Academic Achievement</td>
<td>Wide Range Achievement Test (WRAT-III) Reading</td>
</tr>
<tr>
<td></td>
<td>WRAT-III Arithmetic</td>
</tr>
<tr>
<td></td>
<td>WRAT-III Spelling</td>
</tr>
<tr>
<td>Psychosocial Functioning</td>
<td>Conners Parent Rating Scales (CPRS) Global Index</td>
</tr>
<tr>
<td></td>
<td>CPRS ADHD Index</td>
</tr>
<tr>
<td></td>
<td>CPRS DSMIV Total</td>
</tr>
</tbody>
</table>

Note: All scores were converted into standard scores with a mean of 100 and standard deviation of 15.

Descriptive discriminant analyses were performed to investigate the
discriminative power of the neuropsychological cluster scores for the three groups under study. This type of analysis was chosen because of its ability to reveal differences among groups (Stevens, 2002) and because diagnostic information was already available. In
these analyses, the neuropsychological cluster scores were used to attempt to predict inclusion in the correct diagnostic category: Epilepsy, ADHD, or Epilepsy and ADHD. The cluster variables were entered into the analyses one at a time to determine how each predicted group membership individually.

Exploratory discriminant analyses were then conducted using meta-cluster scores. The Executive Function and Attention Clusters were combined to form the Fluid Intelligence Cluster and entered into the analysis to investigate the potential for increased discriminability with an overall measure of fluid intelligence. Likewise, the General Intelligence, Verbal Language, Memory, Visual Perception, and Academic Achievement Clusters were combined to form the Crystallized Intelligence Cluster and entered into the analysis to examine the potential diagnostic discriminability of this meta-cluster.

The Parent Report of Psychosocial Functioning Cluster was not included in these exploratory analyses because, individually, it demonstrated the most robust discriminability, indicating that it may have had the potential to inadvertently capitalize on its ability to distinguish between diagnoses when examining discriminability of the meta-clusters.

*Missing Data*

Data were missing for some children for a variety of reasons. If only one measure of a cluster score was missing, this score was replaced by the mean of the scores on the remaining measures in that cluster. If more than one score from a cluster was missing, data for that cluster were not included in the analysis.
RESULTS

Of the 427 assessment cases, 44 had an epilepsy diagnosis in the absence of ADHD, 176 were diagnosed with ADHD without epilepsy, and 49 children carried diagnoses of both epilepsy and ADHD. Further, there were no significant differences in ages across all groups. The ratio of boys compared to girls with ADHD was representative of the 4:1 ratio in the general population (Barkley, 1997b). Table 2 presents group demographics.

<table>
<thead>
<tr>
<th>TABLE 2. Demographic characteristics of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Total Number</td>
</tr>
<tr>
<td>Age (yr)</td>
</tr>
<tr>
<td>SD</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
</tbody>
</table>

*Epilepsy

A series of separate discriminant function analyses were computed using the eight cluster scores (General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, Academic Achievement, and Parent Report of Psychosocial Functioning) to predict membership in the correct diagnostic category (Epilepsy, ADHD, or Epilepsy and ADHD). The criterion that the sample size of the smallest group should exceed the number of predictors was met. Each cluster score was used as a predictor in separate analyses for the purpose of comparing classification tables to determine which
cluster resulted in the highest percentage of correctly classified participants and was therefore, the best predictor of group membership. Table 3 presents group means and standard deviations by diagnosis.

**TABLE 3. Cluster means and standard deviations by diagnosis:**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>EP*</th>
<th>ADHD</th>
<th>EP/ADHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Intelligence</td>
<td>98.8^ (15.4)</td>
<td>94.7 (14.8)</td>
<td>100.8 (15.1)</td>
</tr>
<tr>
<td>Verbal Language</td>
<td>95.3 (13.5)</td>
<td>88.3 (17.3)</td>
<td>102.4 (20.0)</td>
</tr>
<tr>
<td>Attention</td>
<td>91.5 (10.5)</td>
<td>90.1 (16.8)</td>
<td>91.8 (11.5)</td>
</tr>
<tr>
<td>Executive Function</td>
<td>90.6 (14.4)</td>
<td>91.0 (16.5)</td>
<td>97.5 (14.6)</td>
</tr>
<tr>
<td>Memory</td>
<td>87.1 (16.6)</td>
<td>81.9 (14.2)</td>
<td>89.6 (10.8)</td>
</tr>
<tr>
<td>Visual Perception</td>
<td>97.0 (11.7)</td>
<td>91.9 (18.2)</td>
<td>96.5 (8.1)</td>
</tr>
<tr>
<td>Academic Achievement</td>
<td>95.0 (13.26)</td>
<td>87.7 (16.1)</td>
<td>92.2 (12.1)</td>
</tr>
<tr>
<td>Psychosocial Functioning</td>
<td>117.4 (19.9)</td>
<td>129.9 (16.2)</td>
<td>137.4 (19.5)</td>
</tr>
</tbody>
</table>

*Epilepsy

^ Scores have a mean of 100 and a standard deviation of 15.

The discriminant function analyses for the Intelligence, Verbal Language, Attention, Executive Function, Memory, Visual Perception, and Academic Achievement Cluster scores resulted in a correct overall classification rate (Epilepsy, ADHD, or Epilepsy and ADHD) of 65.4%. However, these results are insignificant (overall Wilks's lambda, \( p > .01 \)) and reflective of 100% predicted membership in the ADHD group for all children in the Epilepsy, ADHD, and Epilepsy and ADHD groups. Because the ADHD group had a larger sample size than the other two groups, it is likely that the
probability of inclusion in the ADHD group was artificially inflated. Table 4 presents results of the seven of eight clusters.

**TABLE 4.** Discriminant analysis classification results using General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, and Academic Achievement Clusters, entered separately, as predictors

<table>
<thead>
<tr>
<th>Predicted group membership</th>
<th>Number of cases</th>
<th>EP*</th>
<th>ADHD</th>
<th>EP/ADHD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EP</td>
<td>44</td>
<td>0 (0%)</td>
<td>44 (100%)</td>
</tr>
<tr>
<td></td>
<td>ADHD</td>
<td>176</td>
<td>0 (0%)</td>
<td>176 (100%)</td>
</tr>
<tr>
<td></td>
<td>EP/ADHD</td>
<td>49</td>
<td>0 (0%)</td>
<td>49 (100%)</td>
</tr>
</tbody>
</table>

*Epilepsy

Note. Percent of grouped cases correctly classified: 65.4%.

The Parent Report of Psychosocial Functioning Cluster demonstrated the highest between group discriminability. The overall Wilks's lambda was significant, $\Lambda = 0.89$, $\chi^2(2, N = 269) = 12.92, p < .01$. This indicates that the predictor differentiated significantly among the diagnostic groups. Table 5 presents these results.

**TABLE 5.** Discriminant analysis classification results using Parent Report of Psychosocial Functioning Cluster as predictor

<table>
<thead>
<tr>
<th>Predicted group membership</th>
<th>Number of cases</th>
<th>EP*</th>
<th>ADHD</th>
<th>EP/ADHD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EP</td>
<td>44</td>
<td>5 (11%)</td>
<td>39 (89%)</td>
</tr>
<tr>
<td></td>
<td>ADHD</td>
<td>176</td>
<td>1 (.01%)</td>
<td>175 (99.4%)</td>
</tr>
<tr>
<td></td>
<td>EP/ADHD</td>
<td>49</td>
<td>0 (0%)</td>
<td>49 (100%)</td>
</tr>
</tbody>
</table>

*Epilepsy

Note. Percent of grouped cases correctly classified: 66.9%.
Based on these results, the Parent Report of Psychosocial Functioning Cluster demonstrates the strongest, but still weak, discriminant predictive accuracy in relation to the Epilepsy, ADHD, and Epilepsy and ADHD groups, whereas there is no significant relationship between these diagnoses and the General Intelligence, Verbal Language, Attention, Executive Functions, Memory, Visual Perception, and Academic Achievement Clusters in this sample.

Exploratory analyses were also conducted to determine whether more comprehensive clusters, a Fluid Intelligence Cluster and a Crystallized Intelligence Cluster, would be better at discriminating between epilepsy and ADHD than clusters distinguished by neurocognitive domain. Discriminant analyses were conducted to determine whether the Fluid Intelligence Cluster, composed of the Executive Function and Attention Clusters, and the Crystallized Intelligence Cluster, comprised of the General Intelligence, Verbal Language, Memory, Visual Perception, and Academic Achievement Clusters, could accurately predict inclusion in the Epilepsy, ADHD, or Epilepsy and ADHD groups.

The discriminant function analysis for the Fluid Intelligence Cluster resulted in a correct overall classification rate of 34% of the children in our sample. In order to take into account chance agreement, we computed a kappa coefficient and obtained a value of .09, which is insignificant. The discriminant function analysis for the Crystallized Intelligence Cluster resulted in an accurate classification rate of 43% in our sample. The kappa coefficient was insignificant at .05. These results indicate that in the present sample, meta-clusters of psychological measures were not necessarily better than cluster
scores at accurately predicting inclusion in the diagnostic groups of Epilepsy, ADHD, and Epilepsy and ADHD.
DISCUSSION

The aim of the present study was to determine whether clusters of neuropsychological test scores could accurately predict membership in the diagnostic categories of Epilepsy, ADHD, or both Epilepsy and ADHD. Of eight clusters, including neuropsychological domains, academic achievement, and parent report of psychosocial functioning, each comprised of two or three independent, standardized measures, the Parent Report of Psychosocial Functioning Cluster was found to be the only discriminator between child patients with Epilepsy, ADHD, or both disorders. Neither the other clusters nor meta-clusters of fluid and crystallized intelligence meaningfully discriminated between diagnoses in this sample of children.

With the exception of the Parent Report of Psychosocial Functioning Cluster and the meta-clusters, discriminant function analyses using the cluster scores predicted inclusion of all participants in the ADHD group. These results are consistent with the breadth of literature reviewed above illustrating largely comparable impairment across most if not all neuropsychological domains in both epilepsy and ADHD in children with these disorders, consistent with no significant neuropsychological discriminability between them.

The present study provides the first attempt that we are aware of to discriminate between epilepsy and ADHD in children using neuropsychological test scores. Whereas researchers have compared neuropsychological performance in each of these disorders to that of controls and even attempted to discriminate between subtypes of ADHD using
neuropsychological measures, none that we are aware of have compared the neuropsychology of epilepsy to that of ADHD using discriminant function analysis.

A major strength of this study was the breadth of neuropsychological measures used in the analysis. All commonly recognized neuropsychological domains were included, in addition to measures of academic achievement and psychosocial functioning according to parent report, a total of 22 individual measures and 8 neuropsychological and psychological domains. Most studies examining neuropsychological functioning in children with epilepsy or ADHD were limited to one cognitive domain or area of psychosocial functioning.

In regard to the original research hypotheses – that there would be meaningful differences between the neuropsychological profiles of children with ADHD or epilepsy or both that could be detected with discriminant analyses, and that these differences would be accounted for by differences in cluster scores—results were largely insignificant: most cluster scores did not predict diagnostic group better than chance. However, the cluster score of psychosocial functioning comprised of three index scores from the Conners’ Parent Rating Scales (CPRS) was able to predict inclusion in the appropriate diagnostic category at a better than chance level. Potential explanations for these findings are offered in the following sections.

Discriminability of Parent Report of Psychosocial Functioning

Between Epilepsy and ADHD

According to current results, parents discriminated between epilepsy and ADHD better than did neuropsychological measures. A potential reason for this significant
finding is the higher rate of behavioral problems in children with ADHD than in children with epilepsy. According to the diagnostic criteria in the *DSM-IV-TR* (2000), individuals with ADHD demonstrate impairment in school or social function. Also according to the diagnostic criteria, they may interrupt often, intrude on others, and have difficulty waiting their turn, symptoms that are in and of themselves indicative of impaired psychosocial functioning. In addition, children with ADHD are more likely to experience family conflict, be delinquent, smoke, abuse substances (Biederman, 2000), and to have conduct or oppositional disorders (Barnett et al., 2005; Tripp et al., 2006; Verté et al., 2006).

An additional consideration in regard to these significant findings is that each parent rated their child according to their child's behavior, as opposed to their child's diagnosis. Although the parents' behavioral reports may have been affected by what they knew about ADHD or epilepsy, the intent of the CPRS is to provide a measure of what the parents observed.

**Indiscriminability of Neuropsychological Performance Between Epilepsy and ADHD**

Contrary to the hypothesis of the present study, clusters of neuropsychological test performance (as opposed to parent report of psychosocial functioning) in both specific and meta-domains did not discriminate between children with epilepsy and children with ADHD. One probable explanation for the lack of discriminability is the approximately comparable neuropsychological impairment across both diagnoses.

Although not all children with epilepsy or ADHD exhibit neuropsychological impairment, most of the relevant research (reviewed above) reveals that the majority of
children with at least one of these disorders share an increased vulnerability to neuropsychological impairment, and many show signs of global impairment. Indeed, most of the averaged test scores of all three diagnostic groups in this sample fell below national norms. These results suggest a degree of global impairment across most, if not all, neuropsychological domains in children with ADHD and epilepsy.

Another possible explanation for the relatively similar neuropsychological performance in children with epilepsy and ADHD is the effect of medication. A number of researchers have addressed cognitive impairment secondary to antiepileptic medications, suggesting that test performance in children with epilepsy in the current student may have been affected by side effects of antiepileptic medications. Many believe that the sedative side effects of anticonvulsant medications compromise an individual’s cognitive abilities (“Epilepsy Education,” 2003; “Mental Retardation,” 2003; Pellock, 2004).

Nolan et al. (2003) found that children on 3 or 4 antiepileptic medications had significantly lower FSIQ scores than children not taking any or taking only one antiepileptic drug. Similarly, Schoenfeld et al. (1999) found that children who were taking more than one antiepileptic medication performed significantly worse on a fine motor skill test than children who were taking only one seizure medication. Additionally, Bulteau (2000) found that 33% of children receiving 2 or more antiepileptic drugs were in adapted or special education, compared to only 11% of children taking 1 or no antiepileptic drugs.

However, Vermeulen and Aldencamp (1995) reviewed 89 studies conducted over 25 years and found that no real conclusions could be drawn regarding adverse cognitive
effects of antiepileptic medications because methodology, design, and analysis were poor in most of the studies.

Limitations

As with most research endeavors, this study has limitations. One limitation was the heterogeneity of disorders present in the sample. There are over 40 types of seizures, and each of these can have varying brain loci. Indeed, Nolan et al. (2003) found significant differences between common epilepsy syndromes for age of onset, duration of active epilepsy, seizure frequency, polypharmacotherapy, and FSIQ scores. Similarly, different ADHD subtypes are characterized by potentially significantly different behavioral symptoms.

In an overview of the literature on intellectual ability in children with epilepsy, Williams and Sharp (2000) noted that some epilepsies are associated with severe cognitive impairment. For instance, up to 96% of children with Lennox-Gastaut syndrome demonstrate mental retardation, whereas juvenile myoclonic epilepsy and benign rolandic epilepsy are not associated with negative cognitive outcomes. Similarly, cognitive functioning in children with ADHD is affected by severity of attention problems and, presumably, underlying neuropathology.

The lack of a unique neuropsychological profile for seizure disorders as a group and the inclusion of all subtypes of ADHD in our sample may have contributed to the current findings. However, the results of the present study are not intended to describe neuropsychological functioning in specific epilepsy syndromes or ADHD subtypes, but rather look at the group of syndromes and subtypes as wholes. Nevertheless, the
heterogeneity in the present sample renders interpretation of results limited in relation to other heterogeneous samples of epilepsy syndromes and ADHD subtypes. Our results may not generalize to specific types of epilepsy syndromes or ADHD subtypes.

An additional limiting factor in the present study was that the test data was used initially to support the diagnoses. To some extent, the study modeled the steps to develop a diagnosis taken by the psychologist in private practice from which the participants were drawn.

A final limitation to the present study was the lack of a control group. Data from a control group of children without epilepsy or ADHD, matched for age and gender, would have added to the interpretability of results.

Clinical Implications and Directions for Future Research

The results of this study highlight the need for early assessment of children with seizure disorders and ADHD to ensure timely and appropriate treatment considerations. This is particularly the case because of the frequent comorbidity of ADHD in children with seizures. Although treatment should be individualized to the specific needs of the individual patient, knowing what neuropsychological trends to expect in seizure disorders and ADHD can help guide treatment planning (“Needs for Children with Epilepsy,” 2003). A large number of children with epilepsy, and ADHD, stand to benefit from screening and early intervention. At present, providers who work with children with epilepsy are not routinely screening for ADHD (Sherman et al., 2007).
Taken alone, information gleaned from current results is insufficient for making a diagnosis of ADHD, and certainly not of a seizure disorder. However, our results do support the utility of garnering a thorough developmental history and report of current functioning from a parent or caregiver. Data from the parent concerning the child enhances neuropsychological findings by providing a more comprehensive overall clinical picture of a child and indeed, according to current results, may provide the most meaningful information about attention problems in children with epilepsy syndromes.

In addition, the results of the present study stress the need for practitioners to think carefully about the boundary between conclusions they draw on the basis of research literature derived from group data and how to use that information in developing a child's clinical diagnosis. There is no way to avoid clinical judgment in conceptualizing a case, and indeed we ought not to try. Accurate clinical diagnosis requires not just test results: the importance of a thorough clinical interview, developmental history, and behavioral observations cannot be underestimated.

Reasons for the overlap in cognitive impairment in epilepsy and ADHD are at present largely not known. Future research should focus on increasing our understanding of the underlying neurophysiological and social factors that contribute to neuropsychological impairment in these populations.

Another area for future research involves deciding on the best course of treatment for impairment typical of children with epilepsy and ADHD. Cognitive remediation programs have been developed for ADHD (Ortiz-Becher, 2005; Sohlberg & Mateer, 2001) and for attention problems in children and adolescents recovering from brain tumors (Butler & Mulhern, 2005). However, there are no cognitive rehabilitation
programs that we are aware of that are specifically designed to treat attention problems typically seen in epilepsy.
REFERENCES


Psychometric properties of the Rey-Osterrieth Complex Figure: Lezak-Osterrieth versus Demman Scoring Systems. The Clinical Neuropsychologist, 11, 46-53


