COMPARING AND CONTRASTING COGNITIVE AND PERSONALITY FUNCTIONING IN CHILDREN WITH FETAL ALCOHOL SPECTRUM DISORDER AND CHILDREN WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

A DISSERTATION
SUBMITTED TO THE GRADUATE SCHOOL
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BY
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Abstract

The current study utilized the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) and the Personality Inventory for Children, Second Edition (PIC-2) as measures of cognitive and personality functioning for children with Fetal Alcohol Spectrum Disorder with comorbid Attention-Deficit/Hyperactivity Disorder (FASD/ADHD) and children with ADHD. The current study revealed the WISC-IV and PIC-2 each provided unique information to the neuropsychological examination of children with FASD/ADHD and ADHD. Furthermore, the FASD/ADHD group and the ADHD group were found to have significant differences in terms of cognitive and personality functioning. The results also indicated that children with FASD/ADHD and children with ADHD could be differentiated using the WISC-IV and the PIC-2 independently with a high degree of accuracy. The current study further elucidated the unique cognitive and personality profiles of children with FASD/ADHD and ADHD and identified key areas of difference between the two groups. Moreover, the current study documented the utility of the Classification and Regression Tree procedure as a useful diagnostic tool in the differential diagnosis of FASD versus ADHD using commonly used cognitive and personality measures.
Acknowledgements

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CHAPTER I
Introduction

Prenatal exposure to alcohol can have deleterious consequences in several psychological domains, including cognitive, social, emotional, and behavioral functioning. Recent investigations into the prevalence of Fetal Alcohol Spectrum Disorders (FASD) have revealed that as many as 1-5% of the United States population may be affected (May et al., 2009). Given the significant negative effects of prenatal alcohol exposure and the high prevalence of FASD, it becomes evident that a better understanding of the specific adverse outcomes of prenatal alcohol exposure is needed. Individuals with FASD not only face common cognitive deficits, but also a high rate of psychiatric comorbidity (Famy, Streissguth, & Unis, 1998; Fryer, McGee, Matt, Riley, & Mattson, 2007; O'Connor, Shah, Whaley, Cronin, Gunderson, & Graham, 2002). Among the most common comorbid diagnoses for individuals with FASD is Attention-Deficit/Hyperactivity Disorder (ADHD), which has been estimated to be present in 41 to 95% of individuals with FASD (Bhatara, Loudenberg, & Ellis, 2006; Fryer, McGee, Matt, Riley, & Mattson, 2007; Herman, Acosta, & Chang, 2008). The high level of
comorbidity between FASD and ADHD demonstrates the need for investigations comparing and contrasting the two disorders.

Although many individuals with FASD have comorbid ADHD, it is not true that many individuals with ADHD have FASD. The relationship between FASD and ADHD has not been adequately clarified, in that it is not currently known if the ADHD symptomatology present in individuals with FASD is qualitatively different than individuals with ADHD without comorbid FASD. The dearth of information in this area means that the generalizability of ADHD interventions to individuals with FASD is unknown. Furthermore, the lack of research comparing and contrasting FASD and ADHD makes differential diagnosis of FASD and ADHD very difficult, especially when prenatal history may be unknown or unavailable. The current study investigated functioning in cognitive and personality domains of children with FASD with comorbid ADHD and children with ADHD in order to better understand similarities and differences between the two groups, which will help inform intervention research. Additionally, the current study focused on differentiating the groups based on cognitive and personality functioning, which will aid clinicians and researchers in the process of differential diagnosis. Although there is a paucity of research comparing FASD and ADHD, there are multiple studies that have investigated the neuropsychological functioning of each group individually. Evaluation of the research investigating FASD and ADHD separately will allow for a better understanding of each of the disorders, and will provide context for the need to examine the relationship between FASD and ADHD.
Overview of Fetal Alcohol Spectrum Disorder

History of Fetal Alcohol Syndrome.

Throughout history there have been references to the negative traits that children of parents who abuse alcohol may possess, though many of these references were made on moral or religious grounds rather than through recognition of a direct negative impact on the developing fetus. However, information distributed by proponents of the temperance movement in the 19th and 20th centuries discussed the deleterious effects prenatal alcohol exposure could have, including “mental deficiency” and physical abnormalities (Warner & Rosett, 1975). Furthermore, animal research conducted in the early part of the 20th century documented increased mortality, physical abnormalities, and growth deficits in animals prenatally exposed to alcohol (Sanders, 2009). Although there is a history of references referring to negative outcomes from prenatal alcohol exposure, the recognition of a specific phenotype of children affected by prenatal alcohol exposure was not reported until 1973 when the offspring of alcohol-abusing mothers were described as displaying common anomalies including prenatal and postnatal growth deficits, impaired cognitive, motor, and social skills, and a pattern of craniofacial anomalies (Jones, Smith, Ulleland, & Streissguth, 1973). Further research into the impact of prenatal alcohol exposure resulted in the first use of the term Fetal Alcohol Syndrome (FAS), which was first reported by Jones and Smith in 1973 (Jones & Smith, 1973). This report led to recognition of the FAS diagnosis that described the collection of symptoms that commonly occur following heavy prenatal alcohol exposure. The diagnostic criteria for FAS have remained similar since first described by Jones and Smith in 1973. The current diagnostic criteria, as outlined by the Institute of Medicine,
state the criteria for Fetal Alcohol Syndrome as: 1) Confirmed prenatal alcohol exposure, 2) Evidence of the craniofacial anomalies that are characteristic of FAS (e.g. short palpebral fissures, thin upper lip, smooth philtrum, and flat midface), 3) Evidence of growth retardation, including low birth weight, a deceleration in weight over time, and an abnormal weight to height ratio compared to typically developing peers, and 4) Central Nervous System (CNS) abnormalities including microcephaly at birth, abnormalities in CNS structure, and neurological hard or soft signs (Stratton, Howe, & Battaglia, 1996). The diagnosis of FAS clearly calls for a multidisciplinary approach given the constellation of symptoms that must be present. It is likely that collaboration between physicians of differing disciplines, as well as neuropsychologists would result in the most accurate diagnostic sensitivity and specificity. Specifically, the use of neuropsychological testing would allow for accurate documentation of possible CNS dysfunction (Lezak, Howieson, & Loring, 2004).

Although the diagnostic criteria for FAS allow for recognition of the deleterious effects of prenatal alcohol exposure, the criteria are very specific, thus leading to the exclusion of individuals affected by prenatal alcohol exposure who do not display the full constellation of symptoms needed for an FAS diagnosis. The term Fetal Alcohol Effects (FAE) was developed to describe the harmful outcomes of prenatal alcohol exposure in individuals with subclinical features of FAS (Hoyme et al., 2005). Although FAE allowed for the recognition of subclinical features of FAS, it lacked clinical utility because it was often used to describe any individual with prenatal alcohol exposure with accompanying structural anomalies, cognitive deficits, or behavior problems (Stratton, Howe, & Battaglia, 1996). Specifically, the only prerequisite for an FAE diagnosis was a
history of prenatal alcohol exposure and some kind of negative outcome. These problems led to recommendations that the term Fetal Alcohol Effects be discontinued (Aase, Jones, Clarren, 1995). With the lack of specificity that was present with FAE, a demand was created for more specific criteria that would describe the continuum of effects caused by prenatal alcohol exposure. Specifically, the term Fetal Alcohol Spectrum Disorder (FASD) is currently recognized to refer to the range of deleterious effects caused by prenatal alcohol exposure. Fetal Alcohol Spectrum Disorder appears to have first been used by Barr and Streissguth in 2001, and has been adopted by the National Institute of Alcohol Abuse and Alcoholism, as well as the Centers for Disease Control and Prevention (Barr & Streissguth, 2001; Sokol, Delaney-Black, & Nordstrom, 2003). However, it should be noted that the term FASD is not considered a diagnostic category, and is only used to refer to the several diagnostic terms that are available to describe the continuum of effects of prenatal alcohol exposure (Bertrand, Floyd, & Weber, 2005).

**History of Fetal Alcohol Spectrum Disorder.**

Given the need for clear criteria to describe individuals affected by prenatal alcohol exposure who do not exhibit all of the criteria needed for an FAS diagnosis, the Institute of Medicine commissioned a committee to investigate the effects of prenatal alcohol exposure, and to assist in the diagnosis and treatment of individuals negatively impacted by prenatal alcohol exposure. The committee outlined five diagnostic categories that described the different outcomes that could result from prenatal alcohol exposure including 1) FAS with confirmed prenatal alcohol exposure, 2) FAS without confirmed prenatal alcohol exposure, 3) Partial FAS with confirmed prenatal alcohol exposure, 4) Partial FAS without confirmed prenatal alcohol exposure, and 5) Alcohol-Related Neurodevelopmental Disorder (ARND) without confirmed prenatal alcohol exposure.
exposure, 4) Alcohol-related Birth Defects, and 5) Alcohol-related Neurodevelopmental Disorder (Stratton, Howe, & Battaglia, 1996).

Although the Institute of Medicine guidelines included criteria for each of the diagnostic categories, there was criticism of the proposed criteria because they did not give objective standards to determine if specific criteria were met (e.g. what is the definition of low birth weight, microcephaly, etc.; Hoyme et al., 2005). Therefore, in addition to the diagnostic categories suggested by the Institute of Medicine, several other diagnostic guidelines were created using different methods for making the diagnosis. Astley (2004) developed a diagnostic system that utilizes a Likert-type scale in four different domains that are thought to be characteristic areas of deficits seen in alcohol-exposed individuals (Prenatal alcohol exposure, FAS facial dysmorphology, CNS damage or dysfunction, and growth deficits). Published Canadian guidelines have attempted to combine features of the Astley and Institute of Medicine (IOM) guidelines by utilizing the Likert scoring from the Astley guidelines and retaining the categories from the IOM guidelines (Chudley et al., 2005). Additionally, Hoyme and colleagues (2005) have published clarification of the IOM guidelines by including more objective criteria for determining the deficits that are needed to meet specific criteria (e.g. palpebral fissures should be ≤ 10th percentile).

The multiple guidelines that have been published show that a clear consensus has not been reached in terms of diagnosing Fetal Alcohol Spectrum Disorders. However, the diagnostic categories first outlined in 1996 by the Institute of Medicine appear to be generally accepted as the categories to include under the umbrella term of Fetal Alcohol Spectrum Disorders. Specifically, the term Fetal Alcohol Spectrum Disorder typically
applies to individuals with FAS both with and without confirmed prenatal alcohol exposure, partial FAS (pFAS), Alcohol-related Birth Defects, and Alcohol-related Neurodevelopmental Disorder. Table 1.1 outlines the criteria for each of the FASD diagnostic categories.

Table 1.1

<table>
<thead>
<tr>
<th>FAS with confirmed Prenatal Alcohol Exposure</th>
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<tbody>
<tr>
<td>A. Confirmed Prenatal Alcohol Exposure</td>
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<tr>
<td>B. Distinct Pattern of Facial Features</td>
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<tr>
<td>- Short Palpebral Fissures</td>
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<tr>
<td>- Thin Upper Lip</td>
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<tr>
<td>- Smooth Philtrum</td>
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<tr>
<td>C. Pre- or Post-Natal Growth Deficiency</td>
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<tr>
<td>- Low Birth Weight for Gestational Age</td>
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<td>- Low weight to height ratio</td>
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<td>- Lack of catch-up growth after birth</td>
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<tr>
<td>D. CNS dysfunction</td>
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<tr>
<td>- Decreased Cranial Size</td>
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<tr>
<td>- Structural Brain Anomalies</td>
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<td>- Neurological Hard or Soft Signs</td>
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<th>FAS without confirmed Prenatal Alcohol Exposure</th>
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<tr>
<td>B, C, and D from above</td>
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<th>Partial FAS (pFAS)</th>
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<tbody>
<tr>
<td>A. Confirmed prenatal alcohol exposure</td>
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<tr>
<td>B. Evidence of some of the characteristic facial dysmorphism</td>
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<tr>
<td>C. Evidence of</td>
</tr>
<tr>
<td>- Growth retardation</td>
</tr>
<tr>
<td>- CNS abnormalities</td>
</tr>
<tr>
<td>- Complex pattern of behavior or cognition unexplained by environment or family history</td>
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<table>
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<tr>
<th>Alcohol-Related Birth Defects (ARBD)</th>
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<tr>
<td>A. Any congenital anomaly that is attributable to Prenatal Alcohol Exposure</td>
</tr>
<tr>
<td>- Cardiac</td>
</tr>
<tr>
<td>- Atrial Septal Defects</td>
</tr>
<tr>
<td>- Ventricular Septal Defects</td>
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<tr>
<td>- Skeletal</td>
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<tr>
<td>- Hypoplastic Nails</td>
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<tr>
<td>- Shortened Fifth Digit</td>
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<tr>
<td>- Renal</td>
</tr>
<tr>
<td>- Hypoplastic Kidneys</td>
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<td>- Horseshoe Kidneys</td>
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Cognitive and Personality Functioning

- Ocular
  - Strabismus
- Auditory
  - Conductive Hearing Loss
- Alcohol-Related Neurodevelopmental Disorder (ARND)
  A. Evidence of CNS dysfunction
    - Decreased cranial size at birth
    - Structural brain abnormalities
      - Microcephaly, partial or complete agenesis of the CC, cerebellar hypoplasia
  B. Evidence of NP dysfunction
    - Complex pattern of behavior or cognition unexplained by environment or family history such as:
      - Learning Problems
      - Deficits in School Performance
      - Poor Impulse Control
      - Problems in Social Perception
      - Deficits in Higher Level Receptive and Expressive Language
      - Poor Abstract Reasoning
      - Poor Metacognition
      - Specific Math Deficits
      - Memory Problems
      - Attention Problems
      - Poor Judgment

  (Stratton, Howe, & Battaglia, 1996)

Prevalence of FASD.

The criteria for each of the diagnostic categories describe the significant adverse effects prenatal alcohol exposure can have on individuals affected by FASD. Recent reports by the Center for Disease Control (CDC) estimate that 0.2 to 1.5 cases of FAS occur out of every 1,000 live births (CDC, 2010). May and colleagues (2009) recently proposed that as many as 2-7 out of every 1,000 live births may be affected by FAS. Traditional epidemiological studies have recently estimated the prevalence of Fetal Alcohol Spectrum Disorders to be around 10 per 1,000 in the United States, although the
use of school screening measures shows that this may be an underestimation, with some experts reporting that the prevalence could be as high as 2-5% of the population (May et al., 2009). These estimations of prevalence indicate that Fetal Alcohol Spectrum Disorders are likely one of the most common neurodevelopmental disorders in the United States. The prevalence of FASD is often equal to or greater than disorders that have much greater awareness by medical and school professionals. Specifically, the CDC reports the prevalence of autism spectrum disorders to be 1 in 110 children in the United States and the prevalence of Down Syndrome is estimated to be 11 out of every 10,000 live births (CDC, 2009; CDC, 2010). Therefore, it becomes increasingly clear that a greater understanding of FASD is needed as well as increased awareness due to the fact that FASD is likely more common than many medical and school professionals suspect.

**Overview of Attention-Deficit/Hyperactivity Disorder**

**History of Attention-Deficit/Hyperactivity Disorder.**

The current characterization of Attention-Deficit/Hyperactivity Disorder (ADHD) as defined by the *Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition, Text Revision* (DSM-IV-TR) is a relatively new development in terms of the recognition of the specific behavioral criteria needed to obtain a diagnosis (APA, 2000). However, it appears that descriptions of children exhibiting similar patterns of behavior have existed throughout history. Specifically, there is evidence that as early as 1798 significant deficits in attention had manifested in individuals to such a degree to be considered abnormal (Lange, Reichl, Lange, & Tucha, 2010). Although there was earlier acknowledgment of attention deficits, hyperactivity, and impulsivity, the recognition of this constellation of symptoms as a possible syndrome or disorder began around the
beginning of the 20th century. Specifically, children without obvious cognitive deficits were described as displaying problems consistent with a modern version of ADHD (Lange et al., 2010).

It is not surprising that identification of symptoms of ADHD correspond with the popularity of compulsory education, as this was when greater demands were placed on children to sustain attention, sit still, and delay instant gratification (Miller, Gelfand, & Hinshaw, 2011). There is evidence that many of the criteria for hyperactivity used in the current DSM (DSM-IV-TR) can be traced back to a disorder known as “hyperkinetic disease of infancy”, which was described by German physicians in 1932 as consisting of children exhibiting extreme hyperkinesis, frequent running, and a tendency to climb (Lange et al., 2010). The efficacy of stimulant medication in the treatment of hyperactivity occurred by chance when a physician attempted to treat headaches caused by pneumoencephalograms, a primitive neuroimaging technique that required cerebrospinal fluid to be drained, with stimulant medication. Although the stimulants had no effect on treating the headaches, a significant reduction in problematic behavior was noted to occur (Conners, 2000).

As the field of neuropsychology began to expand as a result of increased knowledge of the effects traumatic brain injury could have on behavior, hypotheses began to develop that the attention, hyperactivity, and impulsivity deficits seen in children could be the result of brain damage or brain dysfunction (Lange et al., 2010). In fact “minimal brain dysfunction” was described as a disease by the medical community and was a precursor to ADHD as it is known today (Conners, 2000). Recognition of hyperactivity as a mental illness first was included in the Diagnostic and Statistical
Manual of Mental Disorders-Second Edition (DSM-II; APA, 1968) when it was labeled “Hyperkinetic reaction of childhood” and was described as a disorder “characterized by overactivity, restlessness, distractibility, and short attention span, especially in young children; the behavior usually diminishes in adolescence” (APA, 1968, p. 50).

Hyperactivity was the symptom of most significant focus throughout history; however, this changed in the 1970s when the attention deficits and impulsivity that often co-occurred with hyperactivity, and often to a more marked degree of deficit, were more heavily emphasized (Lange et al., 2010). This resulted in a significant change in the Diagnostic and Statistical Manual of Mental Disorders-Third Edition (DSM-III) when the disorder was renamed “Attention Deficit Disorder” and could occur with or without hyperactivity (APA, 1980). This change resulted in attention deficits becoming a more prominent component of the disorder. However, the Diagnostic and Statistical Manual of Mental Disorders-Third Edition, Revised (DSM-III-R) resulted in another change in name to the familiar “Attention Deficit-Hyperactivity Disorder” which has remained the same through the current iteration of the DSM (APA, 1987; APA, 1994, APA, 2000).

**Diagnostic criteria of ADHD.**

The path to the current diagnostic criteria for ADHD has shown that the focus of the problematic behavior has oscillated between hyperactivity, impulsivity, and inattention. However, the current criteria for a diagnosis of ADHD recognize that all three of these symptoms may be present in different manifestations. In fact the DSM-IV-TR (APA, 2000) recognizes four different subtypes of ADHD including: Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type; Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type; Attention-
Deficit/Hyperactivity Disorder, Combined Type; and Attention-Deficit/Hyperactivity Disorder, Not Otherwise Specified.

To qualify for ADHD, Predominantly Inattentive type an individual must display inattentive behaviors that are in excess of what would be expected for developmental level. These behaviors include failing to pay attention to details, making careless mistakes, poor sustained attention, difficulty listening when spoken to, failure to finish expected work, difficulty following instructions, poor organizational skills, avoidance of tasks require sustained mental effort, losing needed items easily, distractibility, and forgetfulness (APA, 2000).

Individuals with ADHD, Primarily Hyperactive-Impulsive type would display behaviors consistent with hyperactivity and impulsivity. Hyperactive behaviors include squirming and being fidgety, leaving seat when remaining seated is expected, running or climbing excessively, difficulty engaging in tasks quietly, excessive talking, and acting as if “driven by a motor”. Impulsive behaviors are characterized by blurting out answers before questions have been completed, difficulty waiting for turns, and frequent intrusion or interruption of others. The ADHD, Combined Type is characterized by a combination of inattentive, hyperactive, and impulsive behaviors. ADHD, Not Otherwise Specified is described as a category for individuals displaying clinically significant symptoms of inattention or hyperactivity and impulsivity, but who do not meet the criteria specified in the other subtypes of ADHD (APA, 2000).

An important diagnostic criterion is that some level of impairment as a result of ADHD symptomatology must have been present prior to the age of 7. Although symptoms must be present prior to the age of 7 it is often difficult to diagnose ADHD in
children of preschool age or younger due to a lack of situations that demand sustained attention, especially when overt behavioral problems are not present. However, parents typically will notice excessive motor activity as early as the toddler period. Once children with ADHD reach school age, deficits are often seen in academic performance and in the home environment. This is when most cases of ADHD are typically diagnosed as the elementary school years are typically the time when ADHD symptomatology is most pronounced and disruptive, with an attenuation of symptoms often occurring in adolescence and adulthood, though this is not always the case (APA, 2000).

There appears to be a strong familial component to ADHD with the disorder occurring more frequently among biological relatives than in the general population. Additionally, research has demonstrated that there is likely a strong genetic component to ADHD, with monozygotic twins having greater ADHD concordance than dizygotic twins (Wilens, Biederman, & Spencer, 2002). Furthermore, a biological basis for ADHD has gained recent support with neuroimaging data showing anomalies in the structure and function of the brain of individuals with ADHD, as well as molecular genetic studies showing specific genes that may increase the risk of having ADHD (Rowland, Lesesne, & Abramowitz, 2002).

**Prevalence of ADHD.**

According to the American Psychiatric Association (2000) the prevalence of ADHD is estimated to be between 3% and 7% of school-aged children. The prevalence rate is thought to have increased between the period of the *DSM-III-R* to the current diagnostic criteria due to inclusion of the subtypes of ADHD, which allow for a greater combination of symptoms to be present and still receive an ADHD diagnosis. Gender
appears to be a significant factor in the likelihood of receiving an ADHD diagnosis, as males are diagnosed with ADHD 4 to 10 times as often as females. This difference is thought to be at least partially attributable to a gender bias in referral, as males are more likely to display the disruptive features of ADHD than females (Rowland, Lesesne, & Abramowitz, 2002; Wilens, Biederman, & Spencer, 2002).

ADHD is one of the most common psychiatric disorders affecting the U.S. population and individuals with ADHD are frequently found to display comorbid psychiatric disorders. In children diagnosed with ADHD, the most common comorbid conditions are oppositional defiant disorder, conduct disorder, mood disorders and anxiety disorders (Wilens, Biederman, & Spencer, 2002). A high level of comorbidity has also been shown between FASD and ADHD, with estimates ranging from 41 to 95% of individuals with FASD having comorbid ADHD (Bhatara, Loudenberg, & Ellis, 2006; Fryer et al., 2007; Herman et al., 2008; Walthall et al., 2008). This high level of comorbidity demonstrates a need for investigation into possible differences that may exist between individuals with FASD/ADHD comorbidity, FASD without ADHD, and ADHD without FASD. Specifically, differences in neuropsychological and personality functioning may lead to interventions that are more appropriate for each group’s profile of strengths and weaknesses. This is particularly true as the field of psychology continues to move more towards the use of manualized or evidence-based interventions (APA, 2005; Kratochwill & Shernoff, 2004; NASP, 2010).
Comparing and Contrasting Cognitive Functioning in FASD and ADHD

General Intelligence.

Cognitive deficits are common in neurobiologically-based disorders such as ADHD and FASD (Mayes & Calhoun, 2007). In fact, research has shown individuals with FASD and ADHD perform lower than their typically developing peers in terms of overall cognitive functioning (Frazier, Demaree, & Younstrom, 2004; Vaurio, Crocker, & Mattson, 2011). However, the level of impairment is much more significant in FASD, as prenatal alcohol exposure is the most common cause of preventable mental retardation (Pulsifer, 1996). Although cognitive impairment is common in individuals with FASD, the level of impairment does not always fall into the mentally retarded range. In fact, some individuals with FASD have been found to demonstrate global cognitive functioning in the average to above average range (Kerns, Don, Mateer, & Streissguth, 1997). However, the typical IQ score for individuals with FASD falls in the Borderline to Mildly Impaired range (Vaurio et al., 2011). The cognitive deficits in individuals with FASD are typically evident as early in life as infancy and continue throughout the lifespan (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000; Kerns, Don, Mateer, & Streissguth, 1997; Kaemingk, Mulvaney, & Halverson, 2003; Streissguth, Barr, Bookstein, Sampson, & Olson, 1999).

Individuals with ADHD also have been shown to demonstrate lower cognitive functioning when compared to control groups. However, the level of global cognitive impairment is substantially less than individuals with FASD, as individuals with ADHD typically score about half a standard deviation below controls in terms of Full Scale IQ (FSIQ), though some studies have documented FSIQ scores around 1 standard deviation
below the mean on standard cognitive measures (Ek et al., 2007; Frazier et al., 2004).

Studies have documented a specific profile among individuals with ADHD on common measures of cognitive functioning, with relative strengths in verbal and nonverbal reasoning and relative weaknesses in working memory and processing speed (Mayes & Calhoun, 2004; Mayes & Calhoun, 2007).

**Verbal Comprehension.**

Some research has argued that verbal intelligence appears to be more impaired than nonverbal intelligence in individuals with FASD, though literature reviews investigating these differences have yielded mixed results (Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). Regardless of a difference between verbal and nonverbal intelligence in individuals with FASD, verbal reasoning consistently has been shown to be impaired in individuals with FASD (Astley et al., 2009; Carr, Agnihotri, & Kneightley, 2010; Streissguth et al., 1999). In individuals with ADHD, verbal reasoning has been shown to be an area of relative strength, though studies have shown significantly lower verbal abilities when compared to a control group (Ek et al., 2007; Jakobson & Kikas, 2007). Therefore, it appears that although verbal reasoning may be a relative strength for individuals with ADHD, when compared to peers it is likely to be an area of weakness. Overall, it appears that verbal comprehension is likely impaired relative to typically developing peers in both ADHD and FASD; however, the level impairment is likely to be much more severe in individuals with FASD.

**Perceptual Reasoning.**

Perceptual reasoning is an area where both individuals with ADHD and FASD have been shown to have deficits relative to typically-developing controls (Frazier,
Demaree, & Youngstrom, 2004; Lee, Mattson, & Riley, 2004; Mattson, Calarco, & Lang, 2006; Mattson et al., 2010). In individuals with ADHD, block construction and mental rotation tasks have been identified as areas of difficulty relative to peers (Jakobson & Kikas, 2007). However, relative to processing speed and working memory, perceptual reasoning appears to be an area of relative strength for individuals with ADHD (Ek et al., 2007). Some evidence exists arguing in favor of a relative strength in perceptual reasoning for individuals with FASD as well, though there have also been studies documenting impairment consistent with other areas of neuropsychological functioning (Kerns et al., 1997; Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). Although there is conflicting evidence in the literature regarding a relative strength in perceptual reasoning in individuals with FASD, individuals with FASD are consistently shown to have deficits in this area when compared to typically-developing peers. Specifically, spatial location and line orientation tasks have been shown to be impaired in individuals with FASD (Kaemingk & Halverson, 2000). Furthermore, spatial processing deficits have been proposed as a central feature of a specific neurobehavioral profile in individuals with FASD (Mattson et al., 2010). Generally, it appears that perceptual reasoning is likely to be lower in individuals with ADHD and FASD when compared to control groups. Much like overall cognitive functioning and verbal comprehension, individuals with FASD are likely as a group to display more significant levels of impairment than individuals with ADHD.

**Executive Function.**

Executive functions are comprised of higher-order cognitive processes that coordinate cognitive subprocesses in order to achieve an end goal (Miyake, Friedman,
Emerson, Witzki, & Howerton, 2000). Specific executive functions include novel problem solving, planning, abstraction, judgment, reasoning, and goal-directed behavior (Davis, 2006). Executive dysfunction has been shown to be a characteristic feature of both FASD and ADHD. Shared deficits in executive function is not surprising given the high level of comorbidity that exists between FASD and ADHD (Bhatara, Loudenberg, & Ellis, 2006; Fryer et al., 2007; Herman et al., 2008). Although there is a high level of comorbidity, research has shown that the patterns of executive dysfunction may be different between individuals with ADHD and individuals with FASD and ADHD. Specifically, individuals with FASD and comorbid ADHD have been shown to have deficits in letter fluency and a relative weakness on Trails B versus Trails A, suggesting deficits in cognitive set shifting and sequencing that are not typically present in individuals with ADHD and individuals with no prenatal alcohol exposure (Vaurio, Riley, & Mattson, 2008).

The two groups also share many common deficits regarding executive functions. Deficits in response inhibition typify both disorders, and have been hypothesized to be the primary impairment in ADHD with other deficits being secondary to it (Barkley, 1997; Conner et al., 2000; Willcut, Doyle, Nigg, Faraone, & Pennington, 2005). Additionally, working memory deficits are commonly seen in both disorders. Individuals with ADHD and individuals with FASD have been shown to be impaired in both verbal and spatial working memory (Green et al., 2009; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Rasmussen, 2009). Digit span measures have consistently been used to measure working memory in both groups. In fact, digit span has been shown to be one of the most sensitive measures of prenatal alcohol exposure, and can be impaired even when
other aspects of cognitive functioning are normal (Rasmussen, 2009; Streissguth, Barr, & Sampson, 1990). A recent meta-analysis reported digits backward to be an area of deficit in individuals with ADHD as well (Wilcutt et al., 2005). These studies highlight the potential importance digit span tasks can have on detecting executive dysfunction in individuals with ADHD and with FASD.

**Processing Speed.**

Processing speed has been reported to be a shared deficit in ADHD and FASD. In fact, processing speed has been shown to be a common area of relative weakness for both groups. It has been proposed that processing speed deficits may be partially accountable for the general intelligence deficits in individuals with ADHD (Frazier, Demaree, & Youngstrom, 2004). The neuropsychological profile of individuals with ADHD has been purported to include significant processing speed deficits (Rucklidge & Tannock, 2002). It has also been hypothesized that processing speed deficits may only be present in individuals with subtypes of ADHD that include significant attention deficits (ADHD, Predominantly Inattentive Type; ADHD, Combined Type; Chhabildas, Pennington, & Willcutt, 2001).

Individuals with FASD have also been shown to have characteristic deficits in processing speed, with processing speed deficits also identified as a core component of a neuropsychological profile (Kodituwakku, 2009). Deficits in processing speed have been identified as early as infancy in individuals with FASD (Jacobson, 1998). It appears that poor processing speed in FASD may be the result of both slow central processing and inefficiency in engaging motor units effectively, as indicated by poor performance on tasks measuring reaction time (Riley & McGee, 2005). Deficits have also been shown in
processing speed tasks requiring higher cognitive demands. In fact, more cognitively
taxing processing speed tasks were shown to be even more impaired than simpler tasks
(Burden, Jacobson, & Jacobson, 2005). Processing speed deficits appear to be
characteristic of both FASD and ADHD and are likely to represent an area of relative
weakness within the cognitive profiles of both groups.

Comparing and Contrasting Personality Functioning in FASD and ADHD

Delinquency.

Delinquent behaviors are more common in individuals with ADHD and FASD
than their typically developing peers. A link has been shown between antisocial behavior
and executive dysfunction (Morgan & Lilienfeld, 2000). Therefore, it is not surprising
that individuals with FASD or ADHD, two disorders characterized by executive
dysfunction, are more likely to engage in delinquent behaviors. Individuals with FASD
have been reported to engage in more delinquent behaviors such as stealing, getting into
crimes, lying, and skipping school (Schonfeld, Mattson, & Riley, 2005). Additionally,
individuals with FASD have an increased likelihood of involvement with the criminal
justice system (Fast & Conry, 2009). In fact, Streissguth and colleagues (2004) reported
that out of a sample of 415 individuals with FASD, 60% reported a history of problems
with the law and 50% reported a history of incarceration. Individuals with ADHD also
engage in more antisocial behavior than controls (Young & Gudjonsson, 2006). This has
been shown in individuals with comorbid conduct disorder and in individuals with
ADHD only. Specifically, an ADHD diagnosis is more likely to result in early
engagement in delinquent behavior, a wider variety of delinquent offenses, and more
severe levels of delinquency (Sibley et al., 2011).
Impulsivity.

Signs of impulsivity are necessary for a diagnosis of ADHD, Predominantly Hyperactive-Impulsive Type and ADHD Combined Type (APA, 2000). Additionally, behavioral disinhibition has been proposed as one of the core deficits of ADHD (Barkley, 1997). Caregiver reports of children with ADHD indicate increased aggressive behavior and conduct problems in (DeWolfe, Byrne, & Hawden, 2000). Disinhibition also is prevalent among individuals with FASD, with individuals with FASD having deficits on tasks requiring the inhibition of a prepotent response (O’Leary, 2004; Olson, 1998). Rule-breaking behaviors, conduct problems, and aggressive behavior have also been associated with the impulsivity and behavioral disinhibition that is seen in individuals with FASD (D’Onofrio et al., 2007; Franklin, Deitz, Jirikowic, & Astley, 2008; O’Leary, 2004). Moreover, caregiver ratings of children with FASD have revealed significant perceived disinhibition and disruptive behaviors (Rasmussen et al., 2007; Walthall, O’Connor, & Paley, 2008).

Family Relations.

Strained caregiver-child relationships are common in families of children with ADHD and FASD. In children with FASD, this strain has been demonstrated as early as infancy as evidenced by disruption in mother-infant bonding (Kelly, Day, & Streissguth, 2000). The relationship problems in infancy are likely a combination of negative affect in the infant and a lack of effective responsiveness on the part of the mother (Olson, Oti, Gelo, & Beck, 2009). Children with FASD have also been shown to display higher levels of insecure attachment than typically developing peers (Olson et al., 2009). Increased caregiver stress has also been associated with FASD, especially in children who display
more externalizing problems (Paley et al., 2005). Additionally, children with greater impairment in adaptive and executive functioning had caregivers with higher levels of stress (Paley et al., 2006). Strained family relationships are also more likely in individuals with ADHD. In fact, family relationships that include individuals with ADHD have been characterized as exhibiting strained parent-child interactions, increased overall family conflict, and increased caregiver stress. Furthermore, caregivers of children with ADHD perceive their relationships with the child more negatively than in families with typically-developing children (Barkley, 2006). Caregivers of children with ADHD also consider themselves to be less competent than caregivers of caregivers of children of typically developing children (DeWolfe et al., 2000). Children with ADHD tend to be less compliant with caregiver requests and require more assistance from their caregivers as well (Barkley, 2006).

**Psychiatric Concerns.**

Psychiatric comorbidity is extremely common in both FASD and ADHD. In fact, studies have shown that psychiatric comorbidity may be as high as 87-97% in individuals with FASD (Famy et al., 1998; Fryer et al., 2007; O'Connor et al., 2002). Common psychiatric comorbid conditions in FASD include ADHD, Depressive Disorders, Oppositional Defiant Disorder, Conduct Disorder, and Anxiety Disorders (Franklin et al., 2007; Fryer et al., 2007; O'Connor & Paley, 2009; Walthall et al., 2008). Individuals with FASD are also at-risk for developing alcohol disorders in adolescence and adulthood (Baer et al., 2003). Use of behavior rating scales have shown that children with FASD are more likely to display both internalizing and externalizing problems than typically developing peers (Franklin et al., 2007). Psychiatric comorbidity in individuals with
ADHD has been estimated to fall between 42 to 80%, with community samples falling at the lower end of the range and clinical samples at the higher end (Szatmari, Offord, & Boyle, 1989; Wilens, Biederman, & Spencer, 2002). Common comorbid psychiatric concerns include oppositional behavior, conduct problems, anxiety, depression, and alcohol problems (Barkley, 2006; Wilens et al., 2002; Young & Gudjonsson, 2006). In addition to the high rate of comorbidity between FASD and ADHD, it appears that both disorders parallel each other in terms of shared psychiatric comorbidity. Specifically, Mood Disorders, Oppositional Defiant Disorder, Conduct Disorder, Anxiety Disorders, and Alcohol Use Disorders are all frequent comorbid psychiatric problems in both groups.

**Developmental Deviation.**

Developmental delay is common in individuals with FASD, which is not surprising given that cognitive functioning is typically lower in individuals with FASD. Motor delays have been reported as early as 8 months in individuals with FASD (Streissguth et al., 1999). Additionally, caregiver reports of children with FASD ranging in age from 20 to 68 months revealed deficits in fine and gross motor function (Kalberg et al., 2006). Further evidence of developmental deviation in children with FASD is the high likelihood of irritability, feeding problems, and sleeping problems in infancy (Niccols, 2007). Language delays are also common in individuals with FASD, as well as a higher likelihood of receiving special education services in preschool for general developmental delay (Niccols, 2007). Developmental delay has also been associated with ADHD, though the deviations from typical development are not as pronounced as in FASD (Barkley, 2006). Gilbert and colleagues (2011) demonstrated a delay in reaching
motor milestones for repetitive and sequential movements in individuals with ADHD. Individuals with ADHD appear slightly more likely as a group to have delayed crawling and walking, though this finding is not always consistent (Barkley, 2006). Poor motor coordination is also common in individuals with ADHD, including deficits in handwriting (Pick, Pitcher, & Hay, 2007). Furthermore, sensorimotor deficits have been documented in individuals with ADHD and accounted for significant amounts of variance in academic achievement and cognitive functioning (Davis, Pass, Finch, Dean, & Woodcock, 2009). Delayed acquisition of language milestones has been reported in some individuals with ADHD, including a delay in the internalization of speech and a lack of maturity in internal speech (Barkley, 2006). Generally it appears that some level of developmental delay may be more common in both individuals with ADHD and individuals with FASD when compared to peers without neurobiological disorders. However, the level of delay appears to be more significant and more common in individuals with FASD.

**Social Skills.**

Social skills deficits are commonly seen in individuals with FASD and ADHD. In fact, children with FASD consistently show social skills deficits according to caregiver report (Crocker et al., 2009; Franklin et al., 2007). Communication deficits are also common in FASD, which is likely partially responsible for some of the deficits in social skills (Jirikowic, Kartin, & Olson, 2008). Deficits in social problem solving are commonly seen in individuals with FASD and have been hypothesized as a cause of social skills problems (McGee, 2008). Although a relationship between impaired social skills and communication is common in individuals with cognitive impairments, these
deficits are seen in individuals with FASD even when overall cognitive functioning in controlled (Kelly et al., 2000). Deficits in social skills functioning is also evident in performance on cognitive measures, as the comprehension subtest of the Wechsler Intelligence Scales has been shown to be impaired in children with FASD (Rasmussen, Horne, & Witol, 2006). In addition to general deficits in social skills and social problem solving, individuals with FASD also are more likely to withdraw from social situations, which likely decreases opportunities to develop appropriate social skills (Clarke & Gibbard, 2003).

Socialization skills are also typically lower in individuals with ADHD. These deficits have been shown when compared to control groups including typically developing peers and control groups including individuals with anxiety disorders, mood disorders, and personality disorders (Young & Gudjonsson, 2006). Deficits in peer relationships, including increased peer conflicts, are common in individuals with ADHD, and become more pronounced when oppositionality and conduct disturbance are comorbid (Barkley, 2006). Hodgens and colleagues (2000) found that children with ADHD are less desirable when ranked by their peers in a classroom setting. Caregiver reports of children with ADHD typically reveal significant social skills and communication deficits. However, self-report measures typically reveal an overestimation of social skills and competence (DeWolfe et al., 2000).

**Rationale of the Study**

The current study investigated similarities and differences in cognitive and personality functioning between children with FASD and comorbid ADHD (FASD/ADHD) and children with ADHD without comorbid FASD (ADHD). This study
is of importance due to the high level of comorbidity between FASD and ADHD (41-95%), which suggests that perhaps there are shared underlying neurobiological deficits between the two conditions. Investigation of similarities in cognitive and personality functioning has the potential to elucidate the nature of the relationship between these two groups. Specifically, if the groups are found to share cognitive and personality profiles it will provide valuable information that could allow for interventions for children with ADHD to generalize to children with FASD and vice versa; conversely if the groups are found to have unique profiles, then interventions would need to be based on the pattern of strengths and weaknesses displayed by each group.

Although there is a considerable amount of overlap between some of the cognitive and personality features of children with FASD/ADHD and children with ADHD, the literature suggests that the level of impairment is considerably more pronounced in children with FASD/ADHD. In fact, typical cognitive functioning in children with FASD falls in the borderline to mildly impaired range, while children with ADHD generally have cognitive functioning approximately 6 points lower than typically developing controls (Ek et al., 2007; Frazier et al., 2004; Vaurio, Crocker, & Mattson, 2011). Therefore, even though the two groups have many similarities, children with FASD/ADHD likely face considerably more obstacles than children with ADHD alone. This provides evidence for the possibility that children with FASD and children with ADHD likely have unique profiles regarding cognitive functioning. This argues for the need to conduct investigations into each group’s unique functioning in order to develop effective interventions.
The criteria for an ADHD diagnosis rely on behavioral manifestations of inattention, impulsivity, or hyperactivity and often rely on the reports of collateral sources to confirm the diagnosis. The diagnosis does not require evidence of true neuropsychological dysfunction to receive a diagnosis. As a result, individuals with very different underlying neuropsychological dysfunction could have similar behavioral manifestations of inattention, impulsivity, or hyperactivity and still receive equally valid diagnoses of ADHD. However, the neuropsychological cause of ADHD symptomatology is likely the first place to start for developing appropriate interventions. Differing neuropsychological causes for ADHD could very likely be present in children with FASD/ADHD versus ADHD only. Although executive dysfunction appears to be prevalent and persistent in both FASD and ADHD, there is evidence that the groups differ in terms of specific subdomains of executive functioning. For example letter fluency and Trail-Making tasks have been shown to differentiate individuals with FASD/ADHD and individuals with ADHD (Vaurio, Riley, & Mattson, 2008). Furthermore, neuropsychological measurement of attention has shown that children with FASD/ADHD exhibit deficits in encoding and set shifting, while children with ADHD demonstrated attention deficits in the domains of focused attention and sustained attention (Coles, 2001). These studies show that children with FASD/ADHD may differ qualitatively from children with ADHD in terms of executive functions. Evaluation of neuropsychological differences in children with FASD/ADHD and ADHD will allow for more accurate differential diagnosis, especially when prenatal alcohol exposure is unknown or unquantifiable.
There is a paucity of research comparing personality functioning in children with FASD/ADHD versus ADHD only. The majority of research focuses on the shared behavioral manifestations of ADHD in both groups. However, both groups show similar risk for developing disruptive behavior disorders, mood disorders, and anxiety disorders. Furthermore, social skills deficits, delinquency risk, and familial stress are characteristic of both disorders. The commonalities demonstrate the difficulty present when attempting to differentiate the two disorders. Although investigation of cognitive functioning in children with FASD/ADHD and children with ADHD will likely assist in clarifying differences between the two groups, an investigation of personality functioning has the same potential to inform clinicians with regard to differential diagnosis, and to help develop appropriate interventions.

The prevalence of FASD in the United States is estimated to be as high as 2-5%. Furthermore, estimates of the incidence of FAS have been reported to be as high 2-7 out of every 1,000 live births (May et al., 2009). These estimations show that FASD is one of the most common neurodevelopmental disorders in the United States, but one of the least poorly understood, especially by educational professionals (Koren, Fentus, & Nulman, 2010). The prevalence of FASD is often equal to or greater than disorders that have much greater awareness, such as autism spectrum disorders (1 in 110 children) and Down Syndrome (11 in 10,000 live births) (CDC, 2009; CDC, 2010). Therefore, analysis of cognitive and personality functioning in children with FASD will add to the growing body of literature about functioning in children with FASD, which will serve medical and educational professionals.
ADHD is one of the most common psychiatric disorders in the U.S. population, with diagnoses rising since the 1980s (Rowland et al., 2002; Wilens et al., 2002). Furthermore, ADHD is rarely the only psychiatric concern as comorbidity is extremely common in individuals with ADHD. This high level of comorbidity has the potential to make treatment more difficult due to multiple possible etiologies of symptoms. Research studying the cognitive and personality functioning in children with ADHD allows for greater understanding of the underlying neuropsychological features and associated personality features of ADHD. This greater understanding provides evidence for the development of effective interventions for children with ADHD.

The current study utilized caregiver reports of personality functioning of children with FASD/ADHD and children with ADHD. The specific measure being used is the *Personality Inventory for Children-Second Edition* (PIC-2; Lachar & Gruber, 2001). Cognitive functioning was measured directly through the use of the *Wechsler Intelligence Scale for Children – Fourth Edition* (WISC-IV; Wechsler, 2003). These two measures are widely respected in the field of school psychology and neuropsychology, and have been shown to exhibit sound psychometric properties.

**Significance of the Study**

The investigation of cognitive and personality functioning in children with FASD/ADHD and children with ADHD is a topic that has proliferated in recent years. This has been especially true of the functioning of individuals with FASD due to increased knowledge of the adverse effects prenatal alcohol exposure could have on neuropsychological functioning, even in the absence of physical features. Specifically, impairments in neuropsychological functioning have been well documented in
individuals with FASD; however, investigations into a specific neuropsychological profile in FASD have only recently begun, and have not yet clearly or consistently been described (Rasmussen, Horne, & Witol, 2006). Furthermore, the inclusion of personality functioning when describing the behavioral phenotype or neuropsychological profile of individuals with FASD usually only receives a cursory discussion in the extant FASD literature (see Kodituwakku et al., 2007; Kodituwakku 2009; Mattson et al., 2010; Rasmussen et al., 2006). The use of cognitive and personality measures to investigate functioning in individuals with FASD contributes to the growing base of knowledge and potentially allows for a specific profile of strengths and weaknesses to be elucidated.

Although research pertaining to the cognitive and neuropsychological functioning of children and adults with FASD continues to be published, the majority of the literature relevant to cognitive functioning has utilized cognitive measures that are currently outdated. Specifically, a plethora of research into cognitive functioning in children with FASD has utilized the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III; Wechsler, 1991) and relied upon composite scores that are no longer supported in the current iteration. For example the Freedom from Distractibility Index from the WISC-III was often found to be an area of deficit in children with FASD, but this index score has been removed in the WISC-IV. Additionally, the Verbal and Performance IQ scales have been removed in the WISC-IV. These changes in composite and index scores argue for the need for updated research on the cognitive functioning of children with FASD using the WISC-IV. The current study contributes to achievement of this goal.
Research into the behavioral and personality functioning of children with FASD has revealed increased risk of delinquency, high levels of ADHD symptomatology, impaired family relations, high levels of psychiatric comorbidity, and poor adaptive functioning, with specific deficits in communication and social skills, and increased developmental deviation. These findings all suggest that behavioral and personality dysfunction appear to be consistent features of FASD. However, many investigations of behavioral and personality functioning in individuals with FASD have used domain specific measures to assess these deficits. The use of personality measures that assess multiple domains allows for patterns of behavior and personality functioning to be more thoroughly assessed, including assessment of the possibility of comorbidity (Lachar & Gruber, 2003). Furthermore, multi-dimensional assessments allow for multiple hypotheses to be generated as to the cause of specific behavioral concerns. The use of the PIC-2 in the current study allows for the benefits of multi-dimensional personality assessment to be realized. Moreover, the use of the PIC-2 allows for the personality functioning of individuals with FASD to be comprehensively investigated rather than limited to a specific domain.

The state of the literature regarding cognitive functioning in individuals with ADHD is vast and has consistently demonstrated small but significant deficits in cognitive functioning relative to typically developing controls. However, much like in the FASD literature, the majority of the studies have used cognitive measures that have been replaced with more recent editions. The need for updated investigations into cognitive functioning in ADHD becomes more important given that the composite scales on the WISC-IV consist of different subtests than those found in the WISC-III. It is
possible that children with ADHD may perform differently on these new subtests. Therefore, the need for studies investigating cognitive functioning using updated measures becomes necessary to determine if the cognitive profile described in previous editions of measures of cognitive functioning are consistent with current editions. The current study contributes to this investigation by examining utilizing the most current Wechsler Intelligence Scale, the WISC-IV.

Investigations of personality and behavioral functioning in children with ADHD face many of the same limitations found in the FASD literature. Specifically, many studies have a tendency to utilize single domain measures to answer a specific question about personality functioning in individuals with FASD. It is especially important to utilize multi-domain measures of personality in children with ADHD given the propensity for individuals with ADHD to have comorbid psychiatric disorders. Additionally, the use of a multiple domain measure allows for a clearer picture of the personality profile of children with ADHD to be elicited. The current study is important in that it investigates personality functioning in children with ADHD in a wide range of domains and uses a current and well respected measure of personality functioning.

Research regarding similarities and differences in children with FASD and ADHD is important due to the high level of comorbidity between the two disorders. Investigation of differences between the groups is especially important given the fact that studies have shown the two groups differ in terms of underlying attention deficits, number processing, and the progression of ADHD symptomatology (Coles, 2001; Jacobson et al., 2011; O’Malley & Nanson, 2002). Investigation into differences between children with ADHD and children with FASD/ADHD is important because of the impact
it can have on treatment. Specifically, if the two groups are found to have fundamental differences in cognitive and personality functioning, interventions should be customized for each group’s unique neurobehavioral profile. Additionally, some research has shown that children with FASD/ADHD respond differently to stimulant treatment of ADHD symptomatology than children with ADHD, suggesting that underlying CNS morphology may be different for the two groups (O’Malley & Nanson, 2002). Given the existing research suggesting possible differences in neurobehavioral functioning, it is important to continue this research by investigating how to best differentiate the groups using neuropsychological measures.

Differentiation of children with FASD/ADHD and ADHD only on the basis of cognitive and personality functioning has important ramifications in terms of differential diagnosis. Specifically, the current study has the potential to describe the neuropsychological profile of both groups, thus allowing clinicians to compare neuropsychological functioning to a known clinical profile to aid in arriving at a correct diagnosis. This is especially important when children present with unknown prenatal alcohol exposure, as may be the case for children no longer in the care of biological relatives. Furthermore, clarification of the neuropsychological profile of the two groups will allow for clinicians to more easily identify comorbid conditions as deficits not included in the profile could be hypothesized to have a different etiological origin than the deficits typically seen FASD/ADHD or ADHD only. Arrival at a correct diagnosis has important ramifications for anyone seeking psychological care, as a psychiatric diagnosis can effectively communicate symptomatology to other clinicians, allow for selection of effective evidence-based interventions, and allow for research to be
accurately conducted, including collecting appropriate epidemiological statistics and investigating comorbidities and secondary disabilities. The current study allows for a comparison of cognitive and personality functioning to maximally differentiate the groups, thus describing the neuropsychological profile for each group.

**Research Questions**

R₁ What is the relationship between the WISC-IV and the PIC-2 for the children with FASD/ADHD?

R₂ What is the relationship between the WISC-IV and the PIC-2 for the children with ADHD?

R₃ What is the WISC-IV profile of children with FASD/ADHD and children with ADHD?

R₄ Are there significant cognitive differences between children with FASD/ADHD and children with ADHD as measured by the subtest scores on the WISC-IV?

R₅ What is the profile of adjustment scales on the PIC-2 for children with FASD/ADHD and for children with ADHD?

R₆ Are there significant personality differences between children with FASD/ADHD and ADHD as measured by the PIC-2 adjustment scales?

R₇ What cognitive variables best differentiate the FASD/ADHD and ADHD groups?

R₈ What personality variables best differentiate the FASD/ADHD and ADHD groups?

R₉ What are the specific WISC-IV subtests that most likely classify a diagnosis of FASD/ADHD or ADHD?

R₁₀ What are the specific PIC-2 adjustment scales that most likely classify a diagnosis of FASD/ADHD or ADHD?
Limitations of the Study

A limitation of the current study is that the participants were drawn from a clinical sample. Specifically, the children were referred to a neuropsychologist for an evaluation due to concerns about neuropsychological functioning. Therefore, it is likely that the results of the current study can only be generalized to referred populations. It is likely that cognitive and personality functioning of children with FASD/ADHD and ADHD who have never been referred for a neuropsychological evaluation would differ from the sample used in the current study.

An additional limitation of the current study is the participants all were evaluated at a clinic in a small Midwestern city and came from rural, suburban, and urban areas surrounding the city. Therefore, it is likely the participants are not representative of the U.S. population, which is a threat to external validity.

A further concern about the current study is the lack of information about prenatal exposure to teratogens other than alcohol. This limitation restricts confidence in how much the deficits seen in children with FASD are attributable to prenatal alcohol exposure. Additionally, the current study does not have access to the amount of alcohol each participant was exposed to prenatally. This is a threat to internal validity as the deficits found in children with FASD may be accounted for by other confounding variables such as genetic, familial, and environmental factors.

A final limitation of the current study is that the data were drawn from an archival database, which has inherent disadvantages. Certain confounding variables may be affecting the outcomes of the study, but may be inaccessible because they are not included in the database. For example, the two groups of interest in the current study
may have different socioeconomic status, number of foster care placements, and vast other social-environmental variables that may be contributing to group differences. An additional concern regarding the use of an archival database is the increased possibility of error due to transcribing data from the source, to data collection sheets, and finally into an electronic database. Furthermore, the administration and scoring of the neuropsychological measures used in the current study could have been completed by multiple individuals, increasing the possibility of examiner error.

**Delimitations**

A strength of the current study is sample size of the two groups being investigated. Although FASD and ADHD are two of the most common neurobiological disorders of childhood, it is uncommon to have access to a large number of children with FASD. This is likely due to the absence of FASD in traditional psychological nosology. Additionally, Fetal Alcohol Syndrome, a subtype of FASD, is the only subtype currently recognized in the International Classification of Diseases, Ninth Revision (ICD-9). Therefore, diagnoses of FASD are likely relatively uncommon despite high prevalence. Furthermore, the stigma attached to having a child with prenatal alcohol exposure may limit parents from participating in research into FASD, which could limit the number of participants in some studies of FASD.

Another delimitation of the current study is the use of current measures of cognitive and personality functioning. The FASD and ADHD literature has largely documented cognitive and personality functioning in children with FASD and ADHD using previous editions of common neuropsychological measures. The current study will utilize current editions. Furthermore, the WISC-IV and PIC-2 are both highly respected
measures of cognitive functioning and personality functioning, respectively. They have each been shown to have excellent psychometric properties.

A further strength of the current study is the diagnostic process used in the diagnosis of FASD. Specifically, the diagnosis of FASD was made using a multidisciplinary team utilizing the standards set forth by the 4-Digit Diagnostic Code for diagnosing FASD (Astley, 2004). The team consisted of a licensed psychologist specializing in neurodevelopmental disorders and a physician with specialization in pediatrics and genetics. The children with ADHD in the current study were diagnosed by the same licensed psychologist involved in the FASD diagnoses. This consistency likely increases inter-rater reliability of the diagnoses. Furthermore, the children with ADHD in the current study all were of the ADHD, Combined Type subtype, thus reducing the amount of variability in functioning among children with ADHD. This also addresses concerns about differing underlying neuropsychological deficits among different ADHD subtypes (Chhabildas et al., 2001).

List of Terms

Agenesis of the Corpus Callosum: A birth defect characterized by the congenital absence of the corpus callosum (Dirckx, 2001).

Alcohol-Related Birth Defects (ARBD): A diagnosis currently falling under the umbrella of Fetal Alcohol Spectrum Disorders. The diagnosis can be made when a congenital anomaly that can be attributed to prenatal alcohol exposure is present. Specific birth defects attributable to prenatal alcohol exposure have been outlined by the Institute of Medicine (see Stratton Howe, & Battaglia, 1996).
Alcohol-related Neurodevelopmental Disorder (ARND): A diagnosis currently falling under the umbrella term of Fetal Alcohol Spectrum Disorders. A diagnosis of ARND is made when the consequence of intrauterine alcohol exposure results in CNS dysfunction and neurological hard or soft signs or evidence of a “complex pattern of behavioral or cognitive abnormalities that are inconsistent with developmental level, family history, and environment” (Stratton et al., 1996).

Attention-Deficit/Hyperactivity Disorder (ADHD): A disorder characterized by developmentally inappropriate levels of inattention and/or impulsivity and hyperactivity. Evidence of dysfunction is needed prior to age 7 and impairment must be seen in more than one environment. The inattention and/or impulsivity and hyperactivity must interfere with the academic, social, or occupational functioning. Exclusion criteria for ADHD include a Pervasive Developmental Disorder, Schizophrenia and other Psychotic Disorders, and that the symptoms are not better accounted for by another mental disorder (APA, 2000).

Central Nervous System (CNS): The portion of the nervous system consisting of the brain and spinal cord (Dirckx, 2001).

Craniofacial Anomalies: Abnormalities in the structure of the face or skull (Dirckx, 2001).

Executive Functioning: Executive functions are comprised of higher-order cognitive processes that coordinate cognitive subprocesses in order to achieve an end goal (Miyake et al., 2000). Specific executive functions include novel problem solving, planning, abstraction, judgment, reasoning, and goal-directed behavior (Davis, 2006).
**Fetal Alcohol Effects (FAE):** A term developed to describe the harmful outcomes of prenatal alcohol exposure in individuals with subclinical features of FAS. The term lacked diagnostic specificity as there were no clearly defined diagnostic criteria, and eventually became replaced by the more clearly defined diagnoses currently falling under the FASD umbrella.

**Fetal Alcohol Spectrum Disorder (FASD):** A term referring to the range of deleterious effects caused by prenatal alcohol exposure. FASD is not considered a diagnostic category, but rather an umbrella term under which several prenatal alcohol-related diagnoses fall. Current diagnoses falling under the umbrella of FASD include Fetal Alcohol Syndrome (FAS), partial Fetal Alcohol Syndrome (pFAS), Alcohol-related Birth Defects (ARBD), Alcohol-Related Neurodevelopmental Disorder (ARND), and Fetal Alcohol Effects (FAE).

**Fetal Alcohol Syndrome (FAS):** Refers to a constellation of symptoms commonly present in individuals following heavy prenatal alcohol exposure. The current criteria for a diagnosis of FAS include 1) Confirmed prenatal alcohol exposure, 2) Evidence of the craniofacial anomalies that are characteristic of FAS (e.g. short palpebral fissures, thin upper lip, smooth philtrum, and flat midface), 3) Evidence of growth retardation, including low birth weight, a deceleration in weight over time, and an abnormal weight to height ratio compared to typically developing peers, and 4) Central Nervous System (CNS) abnormalities including microcephaly at birth, abnormalities in CNS structure, and neurological hard or soft signs (Stratton et al., 1996).

**Gray Matter:** The parts of the CNS that are made up primarily of cell bodies and dendrites of nerve cells (Dirckx, 2001).
**Hyperkinesis:** Excessive motor activity (Dirckx, 2001).

**Hyperkinetic Disease of Infancy:** A diagnosis outlined in the 1930s by German physicians recognizing significant hyperactive behavior in children in the absence of brain injury.

**Hyperkinetic Reaction of Childhood (or Adolescence):** A precursor to ADHD, which was first defined in the *Diagnostic and Statistical Manual of Mental Disorders-Second Edition*. The disorder was “characterized by overactivity, restlessness, distractibility, and short attention span.” Exclusion criteria included organic brain damage (APA, 1968).

**Low Birth Weight:** A birth weight of less than 2500 grams (WHO, 2008).

**Mental Retardation:** A mental disorder used to describe persons with intellectual abilities falling 2 or more standard deviations below the population mean, with accompanying deficits in adaptive functioning. Additionally, evidence of intellectual and adaptive skills deficits must be present before age 18 (APA, 2000).

**Microcephaly:** Smallness of the head. Typically refers to a skull with a volume of less than 1350 ml. This condition is often associated with mental retardation (Dirckx, 2001).

**Minimal Brain Dysfunction:** A hypothesis originating in the 1960s purporting that behavioral disorders were likely the result of slight structural or functional brain abnormalities. Additionally, this term was used to describe children with near average to above average intelligence with deficits in areas such as perception, concept formation, language, memory, inhibition, and attention (Lange, 2010).

**Neuroimaging:** A representation of the structure or functioning of the CNS.

**Neurological Hard Sign:** A perceptual or behavioral abnormality that is indicative of damage to a specific part of the brain (Dirckx, 2001).
Neurological Soft Sign: A perceptual or behavioral abnormality that is indicative of more diffuse brain dysfunction (Dirckx, 2001).

Neuropsychology: An applied scientific field interest in investigating the relationship between the brain and behavior. Altered thoughts and behavior as a result altered brain functioning are of particular interest (Zilmer & Spiers, 2001).

Palpebral Fissures: The slit between the lids of the eye (Dirckx, 2001).

Partial FAS (pFAS): A diagnosis currently falling under the umbrella term of Fetal Alcohol Spectrum Disorders. A diagnosis of pFAS occurs when there is confirmed prenatal alcohol exposure, evidence of some of the characteristic FAS facial dysmorphology, and evidence of growth retardation, CNS abnormalities, and complex pattern of behavior or cognition unexplained by the environment or family history (Stratton et al., 1996).

Philtrum: The groove found in the middle of the region between the nose and the upper lip (Dirckx, 2001).

Planum Temporale: Located in the posterior region of the superior temporal gyrus. The planum temporale is responsible for phonological processing and language comprehension (Zilmer & Spiers, 2001).

Strabismus: An eye condition in which both eyes do not remain parallel with each other. Also known as having crossed eyes (Dirckx, 2001).

White Matter: Parts of the CNS that are largely comprised of myelinated axons (Dirckx, 2001).
CHAPTER II

Review of the Literature

The high level of comorbidity between Fetal Alcohol Spectrum Disorder (FASD) and Attention-Deficit/Hyperactivity Disorder (ADHD) suggests that the two disorders likely have several similarities. Both disorders are considered to have neurobiological underpinnings given the overwhelming amount of evidence documenting Central Nervous System (CNS) abnormalities when compared to typically developing peers. In fact, almost all current theories regarding the etiology of ADHD propose a neurological basis. Furthermore, while the postnatal environment likely has an enormous impact on cognitive, behavioral, and social outcomes for individuals with FASD and ADHD, it has little impact on the initial expression of dysfunction, which is neurobiological in nature (Brown, Olson, Croninger, 2010; Schmidt & Petermann, 2009). Given the highly comorbid nature of FASD and ADHD it is important to elucidate how they are similar and different. This is especially important for differential diagnosis and intervention development.
This review is organized into three sections that are relevant to the present investigation. The first section will review the literature pertaining to the structural and functional neuroanatomical abnormalities in these two conditions that have been documented through neuroimaging studies. The second section will review the literature on the cognitive similarities and differences between FASD and ADHD with a focus on the following *Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV; Wechsler, 2003b) composite indices: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. The third section will compare and contrast social, emotional, and behavioral functioning in FASD and ADHD based on the domains found in the adjustment scales of the *Personality Inventory for Children-Second Edition* (PIC-2; Lachar & Gruber, 2001), including Delinquency, Impulsivity and Distractibility, Family Dysfunction, Somatic Concern, Psychological Discomfort, Reality Distortion, Social Skills Deficits, and Social Withdrawal.

**Structural and Functional Neuroanatomical Abnormalities in Fetal Alcohol Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder**

Alcohol is a teratogen that can have many negative consequences for the developing fetus. There are numerous diagnostic criteria currently in place that recognize the adverse outcomes that can occur from prenatal alcohol exposure. Specifically, current criteria for FASD recognize that physical, cognitive, and behavioral deficits are common among individuals with FASD (Astley, 2004). Although individuals with FASD may show differing levels of impairment, current literature outlines a multitude of deleterious neurological and neuropsychological outcomes that occur secondary to prenatal alcohol exposure. Specifically, structural and functional abnormalities in the
CNS are commonly seen in individuals with FASD. Neuroimaging and autopsies of individuals with FASD have revealed significant damage to the central nervous system, evidence of neuronal migratory errors, and failure of tissue to develop (Costa, Aschner, Vitalone, Syversen, & Soldin, 2004; Jones & Smith, 1973; Sowell et al., 2008; Spandoni, McGee, Fryer, & Riley, 2007). Additionally, specific structural patterns have emerged in the literature regarding the CNS of individuals with FASD, including reduced overall brain volume among other more localized abnormalities, which will be discussed below (Astley et al., 2009; Costa et al., 2004; Olney, Farber, Wozniak, Jevtovic-Todorovic, & Ikonomidou, 2000).

ADHD has been consistently recognized as a neurobiological disorder due to a multitude of studies documenting underlying CNS dysfunction as well as strong genetic and hereditary components (Barkley, 2006). Among the evidence documenting the neurological underpinnings of ADHD is a variety of neuroimaging studies that have revealed abnormalities in both the structure and function of the CNS of individuals with ADHD. Although ADHD is currently defined by behavioral criteria, neurological and neuropsychological abnormalities in ADHD are unequivocally present. Regarding structural deficits, individuals with ADHD are frequently found to have volumetric reductions in brain tissue both overall and in specific regions of interest. In fact, the overall brain volume of individuals with ADHD has been shown to be as much as 3-5% smaller to that of typically developing peers (Bush, Valera, & Seidman, 2005; Castellanos et al., 1994; Castellanos et al., 2002; Soliva et al., 2009; Valera, Faraone, Murray, & Seidman, 2007). Additionally, there is some evidence that the right
hemisphere shows even greater volumetric reductions in individuals with ADHD (Casey et al., 1997; Valera et al., 2007).

**Corpus callosum impairment in FASD and ADHD.**

The corpus callosum (CC) is a bundle of nerve fibers in the brain that connects the hemispheres and allows for integration of information through intrahemispheric communication (Lezak et al., 2004). The CC is a subcortical structure that is found beneath the cingulate cortex and runs in an anterior to posterior fashion for approximately half the length of the cerebrum (Mendoza & Foundas, 2008). The CC also is involved in bimanual coordination tasks, spatial and visual working memory, and sustained attention (Spandoni, McGee, Fryer, & Riley, 2007). Damage to this area of the brain may lead to neuropsychological deficits such as impaired intellectual functioning, learning, executive function, attention, motor function and memory (Astley et al., 2009; Norman, Crocker, Mattson, & Riley, 2009).

Magnetic Resonance Imaging (MRI) of individuals with FASD has revealed the CC of individuals with FASD is both smaller in overall volume and shorter than in control groups of non-exposed participants (Astley et al., 2009). Specific reductions in volume have also been found in the anterior and posterior portions of the CC (Riley & McGee, 2005). Moreover, individuals with heavy prenatal exposure to alcohol have been shown to have more variability in the structure of the CC relative to normal controls (Bookstein, Sampson, Streissguth, & Connor, 2001). Diffuse Tensor Imaging techniques have also shown anomalies in the microstructures of the CC in individuals with FASD relative to controls. Furthermore, these microstructural abnormalities were also significantly correlated with intelligence as measured by the WISC-IV and the Wechsler
Adult Intelligence Scale, Third Edition (WAIS-III), with specific correlations found between posterior anomalies and deficits in visual-perceptual and working memory abilities (Wozniak et al., 2009). These results document the direct relationship between CNS integrity and neuropsychological functioning. Early autopsy studies of children with Fetal Alcohol Syndrome revealed partial and complete agenesis of the CC (Vaurio, Crocker, & Mattson, 2011). With the advance of neuroimaging technology, individuals with FASD also have been shown to frequently have abnormalities in the area of the CC such as partial agenesis (Riley et al., 1995; Swayze et al., 1997). In addition to structural differences in the CC, the integrity of the white matter within the CC has also been shown to be compromised in individuals with FASD, especially in the white matter that innervates the bilateral medial frontal and occipital lobes (Fryer et al., 2009). The aforementioned role of the corpus callosum in intellectual functioning, learning, executive function, attention, motor function and memory suggests that the impairment seen in the corpus callosum is likely related to these common deficits seen in individuals with FASD.

Individuals with ADHD have also been found to have structural anomalies in the CC. In fact, a recent meta-analysis investigating MRI findings in groups with ADHD revealed that the CC is typically smaller in ADHD groups than control groups, with the posterior portion (splenium) shown to be a specific area with volumetric reductions (Hutchinson, Mathias, & Banich, 2008; Valera et al., 2006). Furthermore, the anterior portion of the CC has been found to be smaller in individuals with ADHD, though this result is inconsistent as some studies have only documented decreased volume in the anterior portion of the CC for males with ADHD (Bradley & Golden, 2001; Hutchinson
et al., 2008; Tannock, 1998). Smaller volume of the CC in individuals with ADHD is one of the most consistent findings using structural neuroimaging and is likely related to the working memory, motoric, and sustained attention deficits that are characteristic of ADHD.

**Cerebellar impairment in FASD and ADHD.**

The cerebellum is located in the hindbrain, inferior to the occipital lobe and posterior to the brainstem. It has traditionally been associated with motor functions, specifically the production of muscle movements and coordination (Lezak et al., 2004). The importance of the cerebellum in cognitive functioning is evidenced by the fact that although it accounts for approximately 10% of the volume of the brain it contains over 50% of the neurons (Mendoza & Foundas, 2008). The cerebellum is divided into anterior and posterior lobes by the primary fissure. The cerebellum also is divided into hemispheres by a series of gyri and sulci known as folia. The vermis is a portion of the cerebellum that lies between the two cerebellar hemispheres. The vermis is thought to be involved in balance and posture, while the more lateral aspects of the cerebellar hemispheres are thought to be involved in higher order cognitive processes. Input to and output from the cerebellum flows through the three cerebellar peduncles (Inferior, Middle, and Superior), which are connected to the spinal cord, brain stem, and thalamus (Mendoza & Foundas, 2008). Although the cerebellum plays a large role in motor functioning, research has revealed the cerebellum is involved in many higher order cognitive processes as well, including language, attention, and problem solving (Fullbright et al., 1999). Additional cerebellar functions have been shown to include a
role in learning, abstract reasoning, fluency, and visual-spatial processing (Lezak et al., 2004; Mendoza & Foundas, 2008).

Studies utilizing MRI have revealed decreased volume in the cerebellar vermis relative to overall brain size in individuals with FASD (Astley et al., 2009; Archibald et al., 2001). Further MRI studies have shown specific volumetric decreases and displacement in the anterior vermis of the cerebellum (Autti-Ramo et al., 2002; Norman et al., 2009). Imaging data also have implicated the cerebellum as playing a role in number processing tasks in both individuals with FASD and controls. However, the cerebellum is typically only activated when attempting challenging number processing tasks in normally developing individuals, while the cerebellum is activated during even simple number processing tasks in individuals with FASD. This pattern of cerebellar functioning demonstrates that even simple number processing tasks are interpreted as complex for individuals with FASD (Lebel, Rasmussen, Wyper, Andrew, & Beaulieu, 2010; Meintjes et al., 2010). Furthermore, the deficits in the cerebellum, which is involved in coordination and regulation of attention processes, have been hypothesized to be associated with the motor and attention deficits that are frequently seen in individuals with FASD (Vaurio, Crocker, & Mattson, 2011).

Abnormalities in the cerebellum are common in individuals with ADHD. A recent meta-analysis of structural imaging results revealed the cerebellum to be significantly smaller in ADHD groups than controls across a multitude of studies (Valera et al., 2006). In fact, the volume of the cerebellum in individuals with ADHD has been shown to be approximately 3-4% smaller than in controls (Castellanos et al., 2002). Additionally, the posterior inferior vermis of the cerebellum is a specific area that has
been shown to be reduced in volume in individuals with ADHD (Valera et al., 2006). An additional MRI study attempting to link volume reductions with social dysfunction found that individuals with ADHD exhibited an association with reduced gray matter in the posterior lobes of cerebellum and social dysfunction (Soliva et al., 2009). Functional neuroimaging of individuals with ADHD has also revealed abnormalities in cerebellar functioning. Functional MRI studies of ADHD have shown decreased connectivity in the pathways connecting the cerebellum to the cerebral cortex (Purper-Oukil, Lepagnol-Bestel, Gorwood, & Simonneau, 2011). Analysis of brain blood flow through the use of Single Photon Emission Computed Tomography (SPECT) has revealed reduced blood flow in the cerebellum in individuals with ADHD. Additionally, this reduction in blood flow was associated with increased motor dysfunction (Gustafsson, Thernlund, Ryding, Rosen, & Cederblad, 2000). The consistent findings of structural and functional anomalies in individuals with ADHD show that cerebellar functioning is likely a key component in the behavioral manifestations of ADHD. Specifically, the motor deficits, such as delayed motor coordination, sluggish gross motor movements, and fine motor deficits that are common in individuals with ADHD are likely related to cerebellar dysfunction. Given recent findings of the relationship between the cerebellum and higher order cognitive functions, it is possible that this dysfunction may be impacting neuropsychological functioning in individuals with ADHD as well.

**Basal ganglia impairment in FASD and ADHD.**

The basal ganglia are a group of subcortical structures that include the caudate nucleus, putamen, and globus pallidus. The basal ganglia are a group of nuclear masses that lie deep below the cerebral cortex (Mendoza & Foundas, 2008). The basal ganglia
are involved in motor and cognitive functions, including executive function and procedural learning (Mattson, Schoenfeld, & Riley, 2001; Spandoni et al., 2007). The basal ganglia have several direct and indirect connections with the cerebral cortex, including connections with sensorimotor, limbic, and prefrontal regions of the brain (Mendoza & Foundas, 2008). The caudate and putamen are often referred to collectively as the striatum, which is involved in the planning and execution of movement (Lezak et al., 2004). Lesions in the basal ganglia can result in deficits in procedural memory, stimulus-response learning, cognitive flexibility, language, communication, and personality change (Lezak et al., 2004; Packard & Knowlton, 2002).

A variety of neuroimaging studies have revealed abnormalities in the basal ganglia in individuals with FASD. Specifically, decreased volume of the caudate nucleus is a consistently reported finding in the literature (Archibald et al., 2001, Astley, 2009; Mattson et al., 1992; Norman et al., 2009). Additionally, functional MRI utilizing blood oxygen level-dependent (BOLD) response has shown reduced activity in the right caudate nucleus during response-inhibition tasks for individuals with FASD when compared to normal controls (Fryer et al., 2007). Although other parts of the basal ganglia are often reduced in volume, they are reduced in proportion to the reduction in overall brain volume; whereas the caudate nucleus is disproportionately smaller (Archibald et al., 2001; Mattson 2001). Given the frequency of reduced caudate volume in those prenatally exposed to alcohol, the caudate nucleus appears to be one of the more sensitive structures in the brain regarding prenatal alcohol exposure. This is evidenced by the fact that the caudate nucleus becomes more impaired as a function of duration of prenatal alcohol exposure (Willford, Day, Aizenstein, & Day, 2010). In addition to
structural differences in the basal ganglia, research has demonstrated that the function of these structures is impacted by prenatal alcohol exposure as well. Specifically, Magnetic Resonance Spectroscopy of individuals with prenatal alcohol exposure revealed abnormalities in the metabolism of the left caudate nucleus relative to controls, which is thought to be indicative of impaired overall functioning of the neurons (Cortese, et al., 2006). The caudate nucleus is the part of the basal ganglia that is hypothesized to be responsible for higher level cognitive functioning as it receives projections from the prefrontal association cortex (Mendoza & Foundas, 2008). Therefore, some of the executive dysfunction that is commonly seen in individuals with FASD is likely partially attributable to the specific reduction in volume and dysfunction of the caudate nucleus.

The basal ganglia are also commonly affected in individuals with ADHD. In fact dysfunction in the networks connecting the striatum (caudate and putamen) and the frontal lobe have been hypothesized as one of the main neurological bases of ADHD dysfunction (Bush et al., 2005). Neuroimaging studies have repeatedly documented structural and functional differences in the basal ganglia for individuals with ADHD versus control groups. The caudate is the part of the basal ganglia that has most consistently been identified as abnormal in individuals with ADHD. Several structural imaging studies have shown volumetric reductions in the caudate nucleus, though there does not appear to be clear agreement about if size reductions occur bilaterally or unilaterally (Barkley, 2006; Casey et al., 1997; Plizka, Lancaster, Liotti, & Semrud-Clikeman, 2006; Semrud-Clikeman et al., 2000; Soliva et al., 2009; Tannock, 1998; Valera et al., 2006). Additionally, studies coupling structural imaging with measures of motor inhibition have documented a relationship between the size of the basal ganglia
and the level of impairment (Barkley, 2006). Volumetric reductions in the putamen have also been documented, though some studies have shown no significant differences in the size of the putamen in individuals with ADHD (Silk et al., 2009; Tannock, 1998). However, research by Max and colleagues (2002) documented an association with lesions in the putamen region of the basal ganglia and ADHD symptomatology. So it appears that the role of the putamen in ADHD is not yet clearly understood. The globus pallidus has also been shown to be smaller in some MRI studies (Barkley, 2006; Casey et al., 1997; Tannock, 1998). Functional neuroimaging studies have shown hypoactivity and lack of blood flow in the basal ganglia, with the reduced striatum activity being commonly hypothesized to be a component of the behavioral disinhibition seen ADHD (Barkley, 2006; Bradley & Golden, 2001; Dickstein et al., 2006). Functional MRI has also documented reduced connectivity in the networks connecting the striatum to areas of the cerebral cortex (Purper-Ouakil et al., 2011). A relationship between the caudate and deficits in suppressing an interfering response has also been documented with fMRI (Vaidya et al., 2008). Basal ganglia dysfunction and volumetric reductions are common in individuals with ADHD and appear to be related to some of the behavioral dysfunction associated with ADHD such as motor and executive dysfunction.

**Hippocampus impairment in FASD and ADHD.**

The hippocampus is involved in memory formation, specifically in the encoding of new memories as evidenced by the difficulty with new memory formation in individuals with hippocampal damage (Mendoza & Foundas, 2008). The hippocampus is found bilaterally in the medial temporal lobe and runs longitudinally for most of the length of the temporal lobe (Lezak et al., 2004). Evidence of the role of the hippocampus
suggests that it is involved in most forms of learning, except for some simple conditioning and sensorimotor learning (Lezak et al., 2004). Impaired functioning in the hippocampus would likely result in impairment in various memory and learning tasks and also sensory dysfunction.

The hippocampus has been shown to be an area of the brain impacted by prenatal alcohol exposure. Several animal models of alcohol teratogenesis exist that document the deleterious impact of prenatal alcohol exposure on the hippocampus. Specifically, rats that are exposed to alcohol during periods that correspond with the human gestational period exhibit reduced neurons, lower density of dendritic spines, and decreased plasticity in the hippocampus (Berman & Hannigan, 2000). Moreover, the rats with deficits in the hippocampus were found to have functional deficits in spatial learning, which is similar to studies of humans with prenatal alcohol exposure (Hamilton, Koidituwakku, Sutherland, & Savage, 2003; Kaemingk & Halverson, 2000; Kaemingk, Mulvaney, & Halverson, 2003). In addition to animal models, neuroimaging in humans has revealed abnormalities in the hippocampus of individuals with FASD. Specifically, Astley and colleagues (2009) reported that as the severity of prenatal alcohol exposure increased, the volume of the hippocampus decreased. A greater degree of asymmetry in the hippocampus has also been reported in individuals with FASD (Riikonen, Salonen, Partanen, Verho, 1999). Given the role of the hippocampus in memory formation and spatial memory, it is likely that the deficits in verbal learning and spatial memory that are frequently observed in individuals with FASD are related to morphological dysfunction in the hippocampus.
Individuals with ADHD have also been documented to have abnormalities in the hippocampus. Specifically, MRI findings have documented reduced hippocampal volume in individuals with ADHD (Puper-Ouakil et al., 2011). Gray matter reductions in the parahippocampal gyrus have been associated with social dysfunction in individuals with ADHD (Soliva et al., 2009). However, contradictory findings of enlarged hippocampal volumes and no differences in hippocampal volume have also been reported (Frodl et al., 2010; Plessen et al., 2006). The use of PET scans has documented reduced glucose metabolism in the hippocampal region of individuals with ADHD suggesting deficits in the functioning of the neurons in the hippocampus (Tannock 1998). Although there is evidence of anomalies in hippocampal structure and function in individuals with ADHD, it appears further research is necessary to elucidate the exact role of the hippocampus in ADHD.

**Thalamic impairment in FASD and ADHD.**

The thalamus is a small halved structure found on both sides of the third ventricle (Lezak et al., 2004). The thalamus is considered a relay station in the brain for sensory information traveling to the sensory cortices, except for smell (Mendoza & Foundas, 2008). The thalamus is thought to play a key role in regulating behavioral, motoric, and emotional acts. Additionally, the thalamus is involved in arousal and attention (Mendoza & Foundas, 2008). The thalamus is structurally complex, with several subcomponents connected to cortical and subcortical areas. The thalamus also plays a role in the regulation of cortical activity and is involved in learning and memory formation (Lezak
et al., 2004). The thalamus is involved in several feedback loops for cognitive, emotional, and motor systems (Mendoza & Foundas, 2008).

Thalamic abnormalities have been documented in individuals with prenatal alcohol exposure, though not as frequently as other areas of the brain. However, MRI studies have shown a reduction in the size of the thalamus in individuals with FASD (Sowell et al., 2010). Functional neuroimaging has also shown anomalous functioning in the thalamus, including reduced glucose metabolism in the thalamus an indication of metabolic alterations as demonstrated by reduced N-acetylaspartate/choline (NAA/Cho) and lower NAA/creatine (NAA/Cr) ratios (Guerri et al., 2009).

Evidence of thalamic abnormalities in the extant ADHD literature is also present but limited. In fact until a recent publication by Ivanov and colleagues (2010), little support existed for structural differences in the thalamus of individuals with ADHD. This may be due to the fact that the overall volume of the thalamus appears to be similar between ADHD groups and controls. However, more detailed analysis revealed decreased volume in the pulvinar region of the thalamus bilaterally, as well as an association between reduced right lateral and left posterior regions of the thalamus and increased hyperactivity. Moreover, a larger right medial surface was associated with increased inattention (Ivanov et al., 2010). Although these findings are very promising for a potential role of the thalamus in the expression of ADHD symptomatology, replication of these structural findings has not yet occurred. Nonetheless, evidence of functional deficits in the thalamus does exist, though also somewhat limited. Functional MRI investigations have shown a general hypoactivity in the thalamus for individuals
with ADHD (Dickstein et al., 2006). Decreased glucose metabolism has also been documented in the thalamic region of individuals with ADHD (Tannock, 1998).

**Frontal Lobe impairment in FASD and ADHD.**

The human frontal lobe is responsible for carrying out executive functions and is important in maintaining arousal and motivation; approximately one third of the lateral surface of the brain is comprised of the frontal lobe. Additionally, the frontal lobe is involved in the planning and execution of motor activities (Mendoza & Foundas, 2008; Rasmussen, 2005). The frontal lobe is typically reported to consist of 3 main divisions: the primary motor strip, the premotor strip, and the prefrontal cortex (PFC). The primary motor strip is responsible for motor movements, the premotor strip is responsible for motor planning and motor integration, and the PFC is thought to house executive functions and has connections to all other areas of the brain (Lezak et al., 2004).

The frontal lobe of the human brain is negatively impacted by the effects of prenatal alcohol exposure. MRI data have shown that the volume of the frontal lobe is reduced in individuals with FASD with specific reductions in volume in the ventral and inferior portions of the frontal lobe (Astley et al., 2009; Sowell et al., 2002; Sowell et al., 2010). Although the overall volume of the frontal lobe has been shown to be reduced, MRI data have also shown cortical thickness anomalies in the dorsal-lateral portion of the frontal lobe. It should be noted that cortical thickness is thought to be indicative of less efficient neurological functioning, as the cortex often becomes thinner as individuals progress through childhood and adolescence, resulting in more efficient processing (Sowell et al., 2008). Additionally, Single Photon Emission Computed Tomography (SPECT) has revealed abnormalities in functioning of the frontal lobes of individuals
with FASD (Riikonen et al., 1999). Functional MRI data have shown decreased activation relative to controls in the right inferior frontal gyrus, right middle frontal gyrus, right inferior frontal gyrus, and the right dorsolateral prefrontal of cortex individuals with FASD when completing working memory tasks (Astley et al., 2009). Activation patterns during a spatial working memory task have revealed differential frontal lobe activation between participants with FASD and controls. Specifically, individuals with FASD have shown increased activity in the inferior and middle frontal cortex relative to controls during spatial working memory tasks (Malisza et al., 2005). Additional fMRI data collected during a response-inhibition task revealed that individuals with FASD demonstrate increased activation in right middle frontal gyrus and the left medial frontal gyrus (Fryer et al., 2007). Functional MRI data have also suggested that individuals with FASD may perform less efficiently than controls when completing verbal working memory tasks. Specifically O’Hare and colleagues (2009) showed that participants with FASD demonstrated greater overall cortical activation when completing verbal working memory tasks, with specific increased activation in the left dorsal frontal area. Overall, it appears there are a variety of differences regarding frontal lobe structure and function in individuals with FASD relative to individuals without a history of prenatal alcohol exposure. Given the significant differences in structure and functioning it can be hypothesized that the attention problems and executive dysfunction that are commonly observed in individuals with FASD can be at least partially attributed to these frontal lobe anomalies.

Given the role of the frontal lobe dysfunction in several current theories of ADHD etiology, the frontal lobe has been the subject of several structural and functional
neuroimaging studies of individuals with ADHD. MRI has shown the prefrontal cortex to be reduced in volume in individuals with ADHD (Purper-Ouakil et al., 2011; Valera et al., 2006). Although the volume of the prefrontal cortex is generally reduced, there is evidence of slower rates of cortical thinning in the PFC, which in individuals with ADHD is associated with increased hyperactivity and impulsivity (Shaw et al., 2011). This finding is similar to that found in individuals with FASD. Reductions in gray matter volume in the orbitofrontal region of the PFC have also been shown to be associated with increased social deficits in children with ADHD (Soliva et al., 2009). There is evidence that the right hemisphere of the PFC may be differentially affected as indicated by MRI results documenting a correlation between right-sided volume reductions and poorer performance of response inhibition tasks (Barkley, 2006; Casey et al., 1997; Tannock, 1998). Another study pairing MRI results with neuropsychological test data found a relationship between reductions in white matter volume in the right frontal lobe and poorer performance on a sustained attention task (Semrud-Clikeman et al., 2000).

Functional neuroimaging has also revealed a plethora of differences in the functioning of the frontal lobe in individuals with ADHD versus control groups. Recent fMRI studies of the ventrolateral PFC, an area associated with behavioral inhibition, have revealed abnormal activation in this area during behavioral inhibition tasks, such as go-no go tasks and Stroop tasks (Bush et al., 2005; Rubia et al., 1999). Hypoactivation in the dorsolateral PFC and the inferior PFC has also been documented in individuals with ADHD and hypothesized as areas of core dysfunction in ADHD (Dickstein et al., 2006). Differential activation of the right PFC has also been documented on fMRI during attention and inhibition tasks (Barkley, 2006). Furthermore, hypoactivation in the medial
PFC during motor timing and inhibition tasks has been shown (Rubia et al., 1999). Deficits in suppression of an interference response have also been shown to be related to decreased activation in the left inferior frontal lobe and the premotor area of the frontal lobe bilaterally (Vaidya et al., 2005). Blood flow in the frontal lobes is typically reduced in individuals with ADHD and is associated with higher caregiver ratings of behavioral disturbances (Gustafsson et al., 2000; Sieg et al., 1995). PET scan results have documented glucose metabolism in the frontal lobe of individuals with ADHD (Tannock, 1998). The myriad neuroimaging studies documenting abnormalities in the structure and function of the frontal lobe lend credence to the multiple etiological theories positing frontal lobe dysfunction as a primary factor of ADHD symptomatology.

**Parietal Lobe impairment in FASD and ADHD.**

The parietal lobe is posterior to the frontal lobe, superior to the temporal lobe, and anterior to the occipital lobe. The parietal lobe is thought to be involved in the collection, integration, and storage of sensory information, and in forming spatial awareness (Mendoza & Foundas, 2008). Literature examining the teratogenic effects of prenatal alcohol exposure has revealed some deleterious effects on the parietal lobe. Although other areas of the brain have been found to be more heavily impacted by prenatal alcohol exposure, recent literature has identified some anomalies in the structure and function of the parietal lobe in individuals with FASD. MRI data have revealed that white matter is more affected by prenatal alcohol exposure than gray matter, and this is especially true in the parietal lobe, which seems to be more affected relative to the temporal and occipital lobes (Archibald et al., 2001). Additionally, brain size and shape abnormalities have been shown in the inferior parietal and perisylvian region of individuals with FASD.
Imaging has revealed narrowing in this area, with an increase in gray matter density and cortical thickness (Sowell et al., 2008; Sowell et al., 2002). Functional MRI has also shown differences in activation patterns between individuals with FASD and controls during a working memory task, with a decrease in right posterior parietal activation for individuals with FASD (Astley et al., 2009b). Functional MRI data also have shown increased activation in the left and right angular gyri during number processing and proximity judgment tasks relative to controls (Meintjes et al., 2010). Diffuse Tensor Imaging has demonstrated a relationship between white matter abnormalities in the parietal lobe and deficits in math skills in individuals with FASD (Lebel et al., 2010). The deficits observed in the parietal lobe of individuals with FASD are likely related to deficits seen in encoding and storing sensory information, as well as deficits in spatial processing and awareness. Furthermore, dysfunction in the angular gyrus may also account for some of the mathematics and number processing difficulties that are common in individuals with FASD.

The parietal lobe also appears to be an area with abnormalities in individuals with ADHD. Structural anomalies through the use of MRI have revealed volumetric reductions in the parietal lobe of individuals with ADHD (Barkley, 2006; Soliva et al., 2009). Gray and white matter volumes both appear to be reduced in ADHD (Filipek et al., 1997; Purper-Ouakil et al., 2011). Additionally, functional neuroimaging has shown reduced blood glucose metabolism and cerebral blood flow in the parietal cortex of individuals with ADHD (Bush et al., 2005; Dickstein et al., 2006). Decreased connectivity in the fronto-parietal network is also a common finding in ADHD (Barkley, 2006; Purper-Ouakil et al., 2011). Reduced cerebral blood flow in the parietal lobe has
been shown to be associated with increased caregiver ratings of behavioral problems in children with ADHD (Gustafsson et al., 2000). When compared to controls, individuals with ADHD show significantly less parietal activation when attempting to suppress an interference response (Vaidya et al., 2005). Resting state fMRIs also have shown differential brain activity, with the inferior parietal lobe being more active in controls than in those with ADHD (Tian et al., 2008).

**Occipital Lobe impairment in FASD and ADHD.**

The occipital lobe is primarily responsible for visual perception, including motion, form, and color (Mendoza & Foundas, 2008). The literature exhibiting morphological differences in the occipital lobe in individuals with FASD is sparse; however, there have been some studies using neuroimaging techniques that have shown differences in the occipital lobe. Specifically, individuals with FASD have been shown to have excessive superior occipital lobe activation during spatial working memory tasks relative to healthy controls (Spandoni, et al., 2009). An additional fMRI study conducted by Li and colleagues (2008) demonstrated abnormal activation patterns in the occipital lobe during a sustained visual attention task. Specifically, individuals with FASD were shown to have more activation in the superior occipital lobe and less activation in the ventral portion. Also, volumetric reductions have been found in the occipital lobe of individual with FASD (Li., et al., 2008). Sowell and colleagues (2010) found specific volumetric reductions in the left occipitoparietal area of the cortex in individuals with FASD. Although there are fewer studies demonstrating occipital lobe dysmorphology relative to other areas of the brain, it appears that recent studies have shown that the occipital lobe appears to also be affected by prenatal alcohol exposure.
There is limited evidence of structural and functional differences in the occipital lobe of individuals with ADHD. Some MRI findings have found the occipital lobe to be smaller in individuals with ADHD, with specific differences found in the white matter (Barkley, 2006; Filipek et al., 1997). The occipital lobe has also been shown to be more active during resting states when compared to controls, though this has not been replicated and could have been an artifact of the research design (Tian et al., 2008). Given the scarcity of documented occipital lobe abnormalities in the extant ADHD literature, it is imprudent to speculate about a potential role of occipital lobe dysfunction in ADHD at this time.

**Temporal Lobe impairment in FASD and ADHD.**

The temporal lobe is thought to be responsible for auditory perception and integration, the processing of language, and affective processing (Mendoza & Foundas, 2008). Similar to the occipital lobe, there is a dearth of research pertaining to the impact of prenatal alcohol exposure on the temporal lobe. However some research has demonstrated a reduction in white matter in the temporal lobe (Li et al., 2008), while other literature has stated that the lateral and ventral temporal lobe had bilateral volumetric increases in individuals with FASD (Sowell et al., 2010). Furthermore, studies have demonstrated cortical thickening in the temporal lobe in individuals with FASD, which suggests less efficient processing (Sowell et al., 2001). These differences in temporal lobe functioning could account for some of the receptive language deficits that are reported in individuals with FASD.

The literature revealing functional and structural deficits in the temporal lobe for individuals with ADHD is also sparse. However, some MRI studies have shown
volumetric reductions in the temporal lobe of individuals with ADHD; specifically in the areas of the planum temporal and the middle temporal gyrus (Barkley, 2006; Castellanos et al., 2002). Furthermore, a relationship has been found between ADHD symptomatology and cysts in the temporal lobe (Bradley & Golden, 2001). Reduced cerebral blood flow has also been documented in the temporal lobe with associated increases in motor dysfunction (Gustafsson et al., 2000). Glucose metabolism has also been documented to be lower in individuals with ADHD (Tannock 1998). The temporal lobe, especially the left superior temporal gyrus, has been shown to be more active during resting states in individuals with ADHD versus controls (Tian et al., 2008). Temporal lobe impairment has not been documented as frequently as dysfunction in other areas of the CNS in individuals with ADHD; however the existing evidence of temporal lobe dysfunction could explain some of the high degree of comorbidity between ADHD and dyslexia in the ADHD population.

**Neurotransmitter functioning in FASD and ADHD.**

Alterations in neurotransmitter systems have been repeatedly documented in both FASD and ADHD. Prenatal exposure to alcohol has also been shown to interfere with the development of neurotransmitter systems in the brain. The glutamate system has been shown to be disrupted by prenatal alcohol exposure. Glutamate is thought to be an important neurotransmitter involved in the organization of the central nervous system during fetal development and is the primary excitatory neurotransmitter in the CNS (Mendoza & Foundas, 2008). Prenatal alcohol exposure can reduce the number of NMDA glutamate receptors or impair the functioning of existing receptors (Goodlett & Horn, 2001; Ikonomidou et al., 2000). NMDA glutamate receptors are located in the
dendrites of the postsynaptic neuron and interact with glutamate released from the synaptic vesicles. This interaction acts as a stability mechanism for developing synapses (Goodlett & Horn, 2001). This specific effect of alcohol on the developing brain could impact numerous different parts of the brain due to the importance of the glutamate system in organizing fetal brain development. Furthermore, the Gamma Aminobutyric Acid (GABA) system also appears to be affected by prenatal alcohol exposure as research conducted on rats during equivalent periods of human brain development has shown that while NMDA glutamate receptors are blocked, GABA receptors are overly activated, which leads to neuroapoptosis throughout the brain (Ikonomidou et al., 2000). GABA is found throughout the CNS and acts as the primary inhibitory neurotransmitter (Mendoza & Foundas, 2008). It has been hypothesized that the alteration in NMDA receptors in individuals with prenatal alcohol exposure is related to learning deficits that are seen in individuals with FASD. Specifically, research conducted on mice has shown that prenatal exposure to alcohol results in abnormal expression of NMDA receptors, which is correlated with deficits in spatial navigation and spatial memory (Toso et al., 2006).

In addition to the glutamate and GABA systems, the serotonin system has been shown to be affected by prenatal alcohol exposure. Serotonin is thought to be important in the development of the brain, as the serotonergic neurons in the developing brain are what eventually develop into the cortex (Goodlett & Horn, 2001). Rat models have shown prenatal exposure to alcohol can impair development of the serotonergic system and interfere with existing connections between serotonin and target sites (Goodlett & Horn, 2001).
Neurotransmitters have been proposed to play a major role in the expression of ADHD symptomatology. This support has been greatly increased as a result of the efficacy of stimulant medications in the treatment of ADHD (Brown & Zygmont, 2009). Specifically, deficiencies in the dopamine and norepinephrine systems have been exhibited in individuals with ADHD (Barkley, 2006). The PFC, an area hypothesized to be a key component in ADHD dysfunction, has been shown to be very sensitive to the amount of dopamine and norepinephrine present. Drugs such as methylphenidate and amphetamines increase the amount of dopamine and norepinephrine in the PFC, which in turn ameliorate symptoms of ADHD (Arnsten, 2006). Additionally, N-acetyl aspartate (NAA) reductions have been found in the dorsolateral PFC of individuals with ADHD. The neurotransmitter NAA is thought to be an indicator of neuronal integrity, with smaller levels of NAA being indicative of neuronal dysfunction (Bush et al., 2005). Smaller NAA/Creatine ratios in the globus pallidus and lower glutamate levels in the striatum have also been documented in individuals with ADHD (Bush et al., 2005). Significantly lower levels of myo-inositol and NAA have also been found in the cerebellum of individuals with ADHD (Soliva et al., 2010). Myo-inositol is typically found in glial cells and is thought to be an indicator of glucose storage in the area (Soliva et al., 2010). Evidence of the neurotransmitter dysfunction in FASD and ADHD lends further credibility to the neurobiological nature of both of the disorders.

**Review of Cognitive Deficits in FASD and ADHD**

Global cognitive deficits have been documented in individuals with FASD and individuals with ADHD. For FASD, these global cognitive deficits can be quite pronounced as prenatal alcohol exposure is the leading cause of preventable mental
retardation (Pulsifer, 1996). However, cognitive functioning can vary widely in individuals with FASD, as the majority of individuals with FASD do not have mental retardation, though this does not mean than neuropsychological deficits are not present (Riley & McGee, 2005). Individuals with FASD have been shown to have Average to Above Average global intelligence in some studies of individuals with FASD, while others have documented global IQ scores as low as 20 (Kerns, Don, Mateer, & Streissguth, 1997; Streissguth, Randels, & Smith, 1991). However, it is more typical for individuals with FASD to function in the Borderline range of functioning (Vaurio, Crocker, & Mattson, 2011). Although global IQ measures of many individuals with FASD fall above the range of mental retardation, a review of the literature shows that the neuropsychological profile of individuals with FASD is typically not flat, suggesting areas of strength and weakness (Mukherjee, Hollins, & Turk, 2006). The cognitive deficits seen in individuals with FASD appear to be persistent as longitudinal studies of cohorts of children with FASD have documented consistent cognitive findings at multiple time points (Streissguth et al., 1999; Streissguth et al., 1991).

Individuals with ADHD also typically have lower levels of cognitive functioning relative to controls, though a recent meta-analysis estimated the deficits to be approximately six points lower relative to controls, suggesting more benign global cognitive impairments in individuals with ADHD compared to those with FASD (Frazier et al., 2004). The PFC has been identified as a core area of dysfunction in individuals with ADHD, which has led to a multitude of research consisting of both neuroimaging of the PFC, as well as neuropsychological tasks, that are thought to tap in to PFC functioning (e.g. tests of executive functions). A meta-analysis reviewed a series of
studies that assessed executive functioning in individuals with ADHD and documented consistent executive dysfunction, especially in vigilance, response inhibition, working memory, and planning (Willcutt et al., 2005). A cognitive profile of relative weakness in working memory and processing speed as measured by the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III), with relative strengths in verbal comprehension and perceptual reasoning has also been demonstrated in individuals with ADHD (Mayes & Calhoun, 2004).

The use of the *Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV) is common in research of children with FASD and children with ADHD. In fact, ADHD was included as a special group studied when analyzing the external validity of the WISC-IV (Wechsler, 2003b). A group of 89 children with ADHD were administered the WISC-IV and compared to a demographically-matched control group. Results of the study showed characteristic relative weaknesses in working memory and processing speed for the ADHD group (VCI=99.0; PRI=100.1; WMI=96.1; PSI=93.4). Additionally, the largest effect size was seen for the Processing Speed Index. Subtest analysis showed subtests measuring working memory (Arithmetic=8.7) and processing speed (Coding=9.3) to be most impaired in the group with ADHD (Wechsler, 2003b).

Although a group of children with FASD was not included in the validity studies of the WISC-IV, there is a strong history of use of previous editions of the WISC in studies of children with FASD. In addition to the utility of the WISC-IV for research purposes in ADHD and FASD population, the use of the Wechsler Intelligence Scales is also common in clinical practice, thus making further investigations into the cognitive functioning of children with FASD and/or ADHD using the WISC-IV even more needed.
to assist clinicians in the diagnosis and treatment of children with FASD and ADHD. The WISC-IV is comprised of four index scales: the Verbal Comprehension Index; the Perceptual Reasoning Index; the Working Memory Index; and the Processing Speed Index. A description of each of these indices will be described below, as well as a review of relevant literature regarding cognitive functioning in these areas for children with FASD and ADHD.

**Review of verbal comprehension deficits in FASD and ADHD.**

The Verbal Comprehension index of the WISC-IV is a quantitative representation of a child’s crystallized knowledge, which includes verbal processing, verbal problem solving, general fund of knowledge, and verbally-mediated novel problem solving. Intact receptive and expressive language is also needed to successfully complete the tasks comprising the Verbal Comprehension index. Verbal intelligence has been proposed as an area of weakness relative to nonverbal intelligence in individuals with FASD, though this finding is not consistent in the literature (Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). Even though this difference is not always present, measures of verbal intelligence in individuals with FASD have consistently been shown to be impaired relative to controls and test norms (Astley et al., 2009; Carr, Agnihotri, & Kneightley, 2010; Streissguth et al., 1999).

Although the amount of crystallized knowledge may be lower in individuals with FASD, impairments in expressive and receptive language could also result in poor performance of measures of verbal comprehension. In fact, deficits in receptive and expressive language have been documented in individuals with FASD. A recent study investigating a group of children with varying levels of severity of FASD according to
the 4-Point diagnostic code created by Astley (2004) revealed impaired expressive and receptive language functioning for all FASD groups when compared to a control group that was screened for prenatal and postnatal risk factors (Astley et al., 2009). Another recent study revealed expressive and receptive language deficits in children with FASD relative to healthy controls; however, the levels of language dysfunction were commensurate with global cognitive functioning (McGee, Bjorkquist, Riley, & Mattson, 2009). Evidence also exists to suggest that expressive language skills may be more impaired than receptive language skills in individuals with FASD (McGee et al., 2009). Overall, these results suggest that expressive and receptive language deficits are likely at least partially responsible for the impaired performance seen on verbal intelligence tasks. Additionally, the adverse effect of poor receptive and expressive language skills on the development and expansion of crystallized knowledge cannot be overlooked.

Performance on verbal intelligence tasks has been shown to be an area of relative strength for individuals with ADHD, though verbal intelligence has still been shown to be lower than healthy controls (Andreou, Agapitou, & Karapetsas, 2005; Ek et al., 2007; Jakobson & Kikas, 2007). Furthermore, evidence exists that individuals with ADHD appear to show relative weakness on the Information subtest of the WISC, a measure of a child’s general fund of knowledge (Fernell et al., 2007). Although verbal intelligence does not appear to be as impaired in individuals with ADHD as in FASD, there is evidence to suggest the language impairment may be more common in individuals with ADHD than in the general population. Specifically, delayed onset of language has been documented in as high as 35% of a sample of individuals with ADHD and speech problems as high a 10-54% (Barkley, 2006). Additionally, deficits in pragmatics have
also been documented in children with ADHD (Bruce, Thernlund, & Nettelblad, 2006; Kim & Kaiser, 2000). In fact deficits in pragmatic language have been proposed as a key feature in ADHD, with the potential to reduce learning opportunities in early school experiences that are rooted in social context (Camarata & Gibson, 1999).

**Review of perceptual reasoning deficits in FASD and ADHD.**

The Perceptual Reasoning index of the WISC-IV is a measure of a child’s ability to process, organize, manipulate, reason, and form concepts with visual and spatial information. Perceptual reasoning has been proposed as an area of relative strength for individuals with FASD, though the research supporting this is dubious (Kerns et al., 1997; Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). Regardless of the relative strength or weakness of perceptual reasoning in FASD, when compared to controls this is an area of deficit. Specifically, a study utilizing the WISC-III showed visual-spatial ability to be significantly lower in individuals with FASD (Astley et al., 2009). Visual-motor integration appears to be an area of deficit for individuals with FASD as well (Astley et al., 2009; Janzen et al., 1995; Mattson et al., 1998). Spatial navigation and spatial memory are important components of perceptual reasoning and have been shown to be impaired in individuals with FASD (Astley et al., 2009; Hamilton et al., 2003; Kaemingk & Halverson, 2000). Regarding a unique cognitive profile in FASD, some research has exhibited evidence in favor of visual-spatial problems as a primary deficit, with children with FASD showing significantly poorer visual-spatial reasoning skills when compared to control groups with comparable global cognitive functioning (Mattson et al., 2010; Olson et al., 1998).
Research pertaining to perceptual reasoning in ADHD has suggested that it is likely a relative strength (Mayes & Calhoun, 2004). A recent meta-analysis showed that although perceptual reasoning may be a relative strength within the cognitive profile of individuals with ADHD, it still is significantly lower than the perceptual reasoning ability of typically developing control groups (Frazier et al., 2004). Furthermore, specific visual-spatial deficits have been documented in visual identification, block construction, and mental rotation tasks in children with ADHD (Jakobson & Kikas, 2007). There appears to be limited research documenting deficits in perceptual reasoning in individuals with ADHD, suggesting that it is not likely a specific area of deficit in terms of an overall cognitive profile. Furthermore, comparison of perceptual reasoning ability in FASD and ADHD reveals significant deficits for individuals with FASD when compared to typically developing peers, while only slight, though significant, deficits are present for individuals with ADHD.

**Review of working memory deficits in FASD and ADHD.**

The Working Memory index on the WISC-IV is a measure of a child’s ability to store and manipulate information in working memory. All information is presented to the child verbally, thus the Working Memory index is limited to auditory working memory within the WISC-IV. Working memory deficits are prevalent in individuals with FASD. The prevalence of working memory deficits is so significant that it has been proposed as a key feature of the neurocognitive profile of FASD (Kodituwakku, 2009). The Freedom from Distractibility Index (FDI) from the WISC-III has been shown to be impaired in children with FASD (Astley et al., 2009). The FDI was a precursor to the current Working Memory index on the WISC-IV. There is a strong history of utilizing iterations
of the WISC as a measure of working memory in children with FASD, as the digit span subtest is the most commonly used measure of working memory in the FASD literature (Rasmussen, 2009). Digit span has also been shown to be one of the most sensitive measures of prenatal alcohol exposure, as performance decreased as a function of increased prenatal alcohol exposure. Additionally, digit span has been shown to be impaired in individuals with FASD even when performance in other cognitive domains was normal (Streissguth et al., 1990).

Intact working memory is considered critical for success on executive functioning tasks. Thus underlying deficits in working memory have the potential to impact several other higher order cognitive processes (Barkley, 1997; Rasmussen, 2009). Specific working memory deficits have been shown in verbal and spatial working memory in individuals with FASD. Verbal working memory has been shown to be impaired for individuals with FASD when asked to hold information in working memory in the presence of a distraction. This deficit has been shown even in individuals with average intelligence (Conner et al., 2000; Kerns et al., 1997). Working memory deficits also have been shown to become more pronounced in individuals with FASD when the information becomes more complex (Kodituwakku et al., 2001). A recent investigation into the neuropsychological functioning of children with FASD revealed that deficits in spatial working memory produced the largest effects size across a series of executive function measures (Green et al., 2009).

Working memory deficits are a hallmark feature of ADHD and have been hypothesized as the underlying cause for the behavioral disinhibition that is seen in ADHD (Barkley, 1997). In fact, Barkley (1997) proposed that working memory deficits
lead to difficulty retrieving and holding information from the past to assist in formulating a current plan, deficits in performing long sequences of behavior to reach an end goal, and difficulty delaying gratification due to difficulty considering multiple options and selecting the most adaptive plan. The deficits that are seen in the working memory tasks on the WISC-IV have been proposed to be due to actual working memory deficits and not simply due to poor storage or retrieval. Specifically, individuals with ADHD have been shown to display impairment on working memory tasks as the information becomes more complex and greater organization of information in working memory is required (Barkley, 1997). Several meta-analyses have documented working memory deficits in individuals with ADHD when compared to typically developing controls (Frazier et al., 2004; Martinussen et al., 2005; Wilcutt et al., 2005). Among working memory tasks, one meta-analysis showed the strongest effects sizes for deficits in spatial storage and manipulation, though verbal storage and manipulation deficits were also present (Martinussen et al., 2005). Investigations of performance on the WISC-III by children with ADHD showed impaired performance on working memory tasks both ipsatively and normatively (Calhoun & Mayes, 2005). Specific profile analysis of performance on the WISC-III showed impairment on the arithmetic and digit span subtests (Fernell et al., 2007).

Some investigations on working memory in individuals with ADHD have shown that storage capacity does not appear to be impaired, but that the deficits are due to increased errors when manipulating information (Engelhardt et al., 2010). However, research has shown that it takes lower cognitive loads to impede successful manipulation of information in individuals with ADHD (Kolfer et al., 2010). Investigations of working
memory performance in children who were taking medication to treat ADHD and treatment-naïve children with ADHD revealed significantly worse performance in the treatment-naïve children. Furthermore, the medicated group performed at a level similar to typically developing peers on working memory tasks (Semrud-Clikeman et al., 2008). This is promising in terms of the efficacy of pharmacological interventions in the treatment of ADHD; however it is possible that prolonged treatment may be required, as working memory impairment has been documented into adulthood for individuals with ADHD (Marchetta et al., 2008).

**Review of processing speed deficits in FASD and ADHD.**

The Processing Speed index on the WISC-IV is a measure of a child’s ability to rapidly complete graphomotor tasks, while maintaining focused attention under time constraints. Children with FASD tend to have deficits in processing speed when compared to typically developing peers. In fact, processing speed deficits have been proposed as a core feature of the neurocognitive profile of FASD (Kodituwakku, 2007; Kodituwakku, 2009). Slower processing speed is evident as early as infancy in children with FASD (Jacobson 1998). Furthermore, processing speed deficits have also been seen in individuals with FASD when measured using motor-free tasks, thus eliminating the possible confound of motor impairment (Jacobson et al., 1993). Processing speed deficits in children with FASD have been hypothesized to be the result of slow central processing and inefficiency in effectively engaging motor units, as evidenced by impaired performance on reaction time measures (Riley & McGee, 2005). Additional research has shown that processing speed deficits become more prominent as the complexity of the task increases (Burden et al., 2005).
Processing speed deficits are common in individuals with ADHD and have been shown to be an area of relative weakness on the WISC-III and the WISC-IV (Calhoun & Mayes, 2005; Mayes & Calhoun, 2007). Furthermore, processing speed has been shown to be especially impaired in children with ADHD even when compared to children with other neurologically-based disorders, such as Bipolar Disorder, Autism, and Learning Disabilities (Calhoun & Mayes, 2005). Some evidence exists for deficits in processing speed on even simple tasks, such as Trails A (Chhabildas et al., 2001). Specific profile analysis of WISC-III performance by children with ADHD revealed relative deficits on the coding subtest, which measures visual-motor integration, processing speed, and visual attention (Mayes & Calhoun 2004). A meta-analysis of children with ADHD showed the Processing Speed index of the WISC to be a significant area of impairment for children with ADHD when compared to typically developing peers (Frazier et al., 2004).

**Review of Social, Emotional, and Behavioral Functioning in FASD and ADHD**

In addition to cognitive functioning, investigation into social, emotional, and behavioral functioning is an important consideration when conducting comprehensive neuropsychological evaluations. This is particularly true since social, emotional, and behavioral deficits may occur secondary to cognitive dysfunction. Specifically, investigation into secondary social, emotional, and behavioral deficits is especially pertinent for children with FASD and ADHD as executive dysfunction is a common neuropsychological deficit and has been shown to be predictive of behavioral problems (Kodituwakku, Kalberg, & May, 2001). Common behavioral sequelae of prenatal alcohol exposure include hyperactivity, aggressive behavior, temper tantrums, disinhibition, lack of remorse, irritability, impaired judgment, and social disinhibition.
Caregiver reports of social, emotional, and behavioral functioning can be important in investigating personality functioning in children with FASD. In fact, caregiver reports have been shown to be predictive of social skills deficits, in areas such as cooperation, initiating conversations, making friends, and engaging in appropriate conflict resolution for children with FASD (Schonfeld et al., 2006). Psychiatric concerns can also be elicited from caregiver reports of personality functioning. This is important as FASD has been shown to have high comorbidity with psychiatric problems (Famy et al., 1998).

Children with ADHD also typically display deficits in social, emotional, and behavioral functioning, which are presumably secondary to structural and functional anomalies in the CNS. Children with ADHD are more likely to be oppositional, aggressive and display conduct problems than typically developing peers (DeWolfe et al., 2000). Furthermore, social skills deficits are common in children with ADHD as reported by caregivers of children with ADHD (DeWolfe et al., 2000). Additionally, peer conflict and poor peer relationships are common in children with ADHD (Barkley, 2006). Lastly, comorbidity with other psychiatric conditions is common in ADHD with common comorbidities including externalizing problems, such as oppositional behavior and conduct problems, and internalizing problems such as anxiety and depression (Wilens et al., 2002; Young & Gudjonsson, 2006).

The use of caregiver rating scales of social, emotional, and behavioral functioning are common in research of children with FASD and children with ADHD. The Personality Inventory for Children-Second Edition (PIC-2; Lachar & Gruber, 2001) is a
well-respected measure of personality functioning in children. However, its use in research of children with FASD and ADHD is sparse. This is likely due to the length of the rating scale, which can take up to 40 minutes to complete. Although the use of the PIC-2 as a research tool is limited, it has numerous clinical applications, thus conveying a need for greater use of the PIC-2 in research protocols to inform clinical practice. Although limited research exists pertaining to PIC-2 scores in the FASD and ADHD literature, the PIC-2 has been shown to be effective in documenting differing patterns of maladjustment in clinical groups. In fact, the standardization sample of the PIC-2 included a sample of clinically referred children who had received DSM-IV diagnoses including Academic and Cognitive Disorders, ADHD, Oppositional Defiant Disorder, Conduct Disorder, Psychotic Disorders, Pervasive Developmental Disorders, Major Depressive Disorder, Other Depressive Disorders, Anxiety Disorders, and Bipolar Disorder. The mean PIC-2 scores for each of these groups was reported to document how the PIC-2 is sensitive to the differential maladjustment patterns inherent in each disorder. The ADHD group was shown to have elevations on scales measuring cognitive impairment (COG=62.9), impulsivity (ADH=68.8), delinquency (DLQ=64.0), developmental deviation (RLT=61.6), psychological discomfort (DIS=63.0), and social skills deficits (SSK=61.6). Although an FASD group was not included in this study, the ability of the PIC-2 to differentiate groups based on caregiver report holds great promise for its utility in differentiating between children with FASD and children with ADHD. The PIC-2 is comprised of nine Adjustment scales: the Cognitive Impairment Scale; the Impulsivity and Distractibility Scale; the Delinquency Scale; the Family Dysfunction Scale; the Reality Distortion Scale; the Somatic Concern Scale; the Psychological
Discomfort Scale; the Social Withdrawal Scale; and the Social Skills Deficits Scale. A description of each of these Adjustment scales will be discussed below, followed by a review of functioning in each of these areas for children with FASD and children with ADHD. However, it should be noted that the Cognitive Impairment scale has been omitted to reduce redundancy, given that cognitive functioning was covered extensively in the above section.

**Review of impulsivity and distractibility in FASD and ADHD.**

The Impulsivity and Distractibility clinical scale on the PIC-2 is a measure of caregiver reported externalizing behaviors that are characteristic of ADHD, including impulsivity, hyperactivity, and disruptive behaviors. Children with FASD have been shown to have high rates of comorbid ADHD, which suggests that elevations on this scale would be common in children with FASD. Children with FASD have been shown to have increased levels of impulsivity, as evidenced by deficits in inhibiting a prepotent response (O’Leary, 2004; Olson, 1998). Inattention is also characteristic of FASD and has been included as a core deficit in a unique neurocognitive profile (Kodituwakku, 2009). Disruptive behavior has been shown to be common in children with FASD, with rule-breaking behaviors, conduct problems, and aggressive behavior being reported frequently (D’Onofrio et al., 2007; Franklin, Deitz, Jirikovic, & Astley, 2008; O’Leary, 2004). It also common for caregivers of children with FASD to report significant levels of impulsivity and disruptive behaviors on rating scales (Walthall et al., 2008).

Children with ADHD would also be expected to have elevations on measures of impulsivity and distractibility, given they are core features of an ADHD diagnosis. In fact disinhibition has been proposed by Barkley (1997) to be one of the primary
underlying deficits that result in the many behavioral manifestations of ADHD.

Caregiver reports of disruptive behavior and aggression are also common for children with ADHD (DeWolfe et al., 2000). Children with ADHD have also been shown to have reduced fear responses when compared to typically developing control children (van Goozen, Snoek, Matthys, Rossum, & van Engeland, 2004). Research investigating PIC-2 profiles in children with ADHD revealed scores approximately two standard deviations above the test mean on the impulsivity and distractibility scale (Lachar & Gruber, 2001). Overall, it would be expected that caregiver reports of impulsivity and distractibility would elevated in children with ADHD.

**Review of delinquency in FASD and ADHD.**

The Delinquency clinical scale on the PIC-2 is a measure of antisocial behavior, modulation of behavior and emotions, and noncompliance. Children with elevations on this scale are often described as disobedient, argumentative, and disruptive. Evidence of delinquency has been found in children with FASD. Specifically, children with FASD have been shown to exhibit lower levels of moral maturity, which was predictive of increased delinquent behavior (Schonfeld et al. 2005). It also appears that children with FASD may tend to live in social environments that put them at greater risk for delinquent behavior, such as family dysfunction, adolescent stress, and increased substance use (Fast & Conry, 2009). Additional research regarding antisocial and delinquent behaviors in individuals with FASD has shown that trouble with the law is a common occurrence (60%), with common criminal acts including crimes against persons, theft, assault, and domestic violence (Streissguth et al., 2004). Investigations of the development of antisocial behavior in children with FASD has shown that children with FASD are more
likely to lie than their typically developing peers, and that as they age they become more adept than their peers at concealing lies effectively (Rasmussen, Talwar, Loomes, & Andrew, 2008). Overall, it appears that individuals with FASD are at much greater risk for delinquency; however, research has shown early detection and diagnosis of FASD to be a resiliency factor against adverse life outcomes such as delinquent behavior (Streissguth et al., 2004).

ADHD also appears to be a risk factor for delinquent behavior. Research investigating psychopathology in adult prison populations has shown prevalence of ADHD to be as high as 45% using DSM criteria (Rosler et al., 2004). Similar research in juvenile prison populations has shown prevalence to be as high as 16% in males and 21% in females (Teplin et al., 2002). The prevalence of prisoners with ADHD clearly exceeds that reported in the general population (3-7%; APA, 2000). Comparison of individuals with ADHD to other clinical groups and healthy controls, showed a significantly higher number of delinquent and antisocial behaviors for ADHD group (Young & Gudjonsson, 2006). ADHD has also been associated with earlier participation in delinquent acts and more severe levels of delinquency (Sibley et al., 2011). Additionally, a measure of socialization showed that individuals with ADHD displayed scores similar to individuals with personality disorders, suggesting significant antisocial traits (Young & Gudjonsson, 2006). However, research has shown that a diagnosis of ADHD in childhood is not predictive of Antisocial Personality Disorder in adulthood (Lahey et al., 2005). A diagnosis of ADHD appears to be associated with increases in delinquency, which is not surprising given that the disorder is characterized by executive dysfunction and impulsivity.
Review of family dysfunction in FASD and ADHD.

The Family Dysfunction clinical scale on the PIC-2 is a caregiver-reported measure of a child’s family environment. Elevations are indicative of increased caregiver-child conflict and family disharmony. Strained family relationships are not uncommon in families of children with FASD, which is not surprising given the higher likelihood of externalizing problems in children with FASD (D’Onofrio et al., 2007). Strained caregiver-child relationships have been demonstrated as early as infancy in children with FASD (Kelly et al., 2000). Insecure forms of attachment are also more common in children with FASD (Olsen et al., 2009). Moreover, caregiver stress has been shown to be increased in families of children with FASD (Paley et al., 2005). Children with FASD also are at greater risk of being the victims of child abuse, as some studies have shown as many as 73% of children with FASD have a history of child abuse (Fast & Conry, 2009). Although family discord and stress are common in families of children with FASD, research has shown that stable and high quality family living environments are a resiliency factor for children with FASD, suggesting that family-focused interventions may be appropriate with the FASD population (Olson et al., 2009).

Family dysfunction is also more common in families of children with ADHD. Strained family interactions, parent-child conflict, and overall family conflict are more common in families of children with ADHD, than families with typically developing children (Barkley, 2006). Parenting stress is also significantly higher in families of children with ADHD, with ADHD being associated with more family problems than other clinical disorders such as Reading Disability (Kaplan, Crawford, Fisher, & Dewey, 1998). Investigations of family functioning in families of children with ADHD have
shown that parents typically report higher levels of family conflict, and that parental psychopathology can exacerbate symptoms of ADHD in children (Pressman et al., 2006). A history of abuse has also been documented to be more likely in children with ADHD than typically developing peers (Briscoe-Smith & Hinshaw, 2006). Overall it appears that ADHD symptomatology likely increases levels of familial conflict and stress; however, there is also evidence that family dysfunction also results in increased symptomatology in children and results in poorer outcomes.

**Review of reality distortion in FASD and ADHD.**

The Reality Distortion clinical scale on the PIC-2 is a measure disability, with elevations on this scale representing significant disabilities. The scale is broken down into two subscales with one subscale measuring developmental anomalies, such as requiring more help than peers and having difficulty interacting well with his/her environment. Elevation on this subscale would be expected in children with IQs falling below 85 and in children with inappropriate social skills. The second subscale is a measure of hallucinations and delusions that would be seen in children displaying more psychotic behavior. Regarding the Reality Distortion scale in children with FASD, elevation would be expected as a result of impaired cognitive functioning and social skills deficits that are characteristic of the disorder. However, there is no evidence of an increased risk of psychotic behavior in individuals with FASD. Adaptive skills deficits are common in individuals with FASD, with specific deficits commonly noted in activities of daily living and social skills (Crocker, Vaurio, Riley, & Mattson, 2009). Functional communication deficits are also more common in FASD, and become more pronounced in late childhood and early adolescence (Kodituwakku, 2007).
Developmental delay is also common in FASD, with delays reported in fine and gross motor skills and speech and language acquisition (Kalberg et al., 2006; Niccols, 2007).

Adaptive skills deficits are also common in individuals with ADHD. In fact, adaptive functioning skills have been shown to be significantly lower than would be expected based on overall cognitive ability in individuals with ADHD (Barkley, 2006). The discrepancy between adaptive skills and cognitive ability has been shown to be significantly greater than a comparison group consisting of individuals with Pervasive Developmental Disorders and Mental Retardation (Stein, Szumowski, Blondis, & Roizen, 1995). Typical performance on adaptive skills measures for children with ADHD is in the Borderline to Low Average range, with social skills and socialization being areas of relative weakness (Barkley, 2006). Research regarding developmental delays in children with ADHD has demonstrated increased prevalence of delayed acquisition of developmental milestones in language, speech, and motor domains (Barkley, 2006; Gilbert et al., 2011; Piek et al., 2007). Evidence also exists suggesting that sensorimotor deficits in children with ADHD account for some of the variance in cognitive and academic functioning (Davis et al., 2009). Psychotic symptoms such as hallucinations and delusions do not appear to be more common in individuals with ADHD than in the general population (Barkley, 2006). However, there is some evidence of stimulant medications triggering psychotic episodes in children (Mosholder, Gelperin, Hammad, Phelan, & Johann-Liang, 2009). Overall, it appears that deficits on the Reality Distortion scale of the PIC-2 would be the result of developmental deviations and below average adaptive skills, rather than a higher incidence of psychotic symptoms in children with FASD and ADHD.
Review of somatic concern in FASD and ADHD.

The Somatic Concern clinical scale on the PIC-2 is a measure of health issues and internal bodily feelings. Elevations on this scale are associated with frequent somatic complaints without a clear physical cause. Research pertaining to somatic complaints in FASD is sparse. In fact, this literature review revealed no results in terms of a direct measure of somatization in individuals with FASD. However, comorbid anxiety disorders have been shown to be common in individuals with FASD, which can manifest as somatic complaints, especially in children with a tendency to convert stress into physical symptoms (Lachar & Gruber, 2001).

Research on somatic complaints in children with ADHD is also lacking. However, one study has shown that boys with ADHD report significantly more stomach aches than typically developing children (Egger et al., 1999). Comorbid anxiety is also common in ADHD, thus suggesting that somatic complaints may also be more common. However, children with ADHD used in the standardization sample of the PIC-2 were shown to have caregiver-reported somatic complaints that were within normal limits (Lachar & Gruber, 2001). Therefore, it appears that more research is needed to better understand the role of somatic complaints in ADHD and FASD.

Review of psychological discomfort in FASD and ADHD.

The Psychological Discomfort clinical scale on the PIC-2 is a measure of negative affectivity, with elevated scores being indicative of internalizing problems such as low self-esteem, emotional lability, nervousness, and worry. Psychiatric concerns are common in individuals with FASD. In fact, psychiatric comorbidity has been documented to be as high as 87-97% in individuals with FASD (Famy, Streissguth, &
Unis, 1998; Fryer, McGee, Matt, Riley, & Mattson, 2007, O'Connor, Shah, Whaley, Cronin, Gunderson, & Graham, 2002). Although externalizing problems are common comorbidities, internalizing problems such as depressive and anxiety disorders are also very common in FASD (Franklin et al., 2007; Fryer et al., 2007; O'Connor & Paley, 2009; Walthall et al., 2008). A study utilizing a parent-report rating scale showed reported internalizing problems in children with FASD to be approximately 1.5 standard deviations above the test mean (Franklin et al., 2008). The use of structured interviews in individuals with FASD has also shown increased levels of depressive (18%) and anxiety disorders (7-23%; Fryer et al., 2007). It has been hypothesized that the high comorbidity of anxiety and depressive disorders in FASD is a result of dysfunction in the hypothalamic-pituitary-adrenal (HPA) axis. Specifically, it appears that HPA regulation is impaired as a result of prenatal alcohol exposure, and that HPA function has been shown to also be disrupted in individuals with depressive and anxiety disorders (Hellemans, Sliwowska, Verma, & Weinberg, 2010). Thus it appears that some of the psychiatric problems seen in FASD may be related to the underlying neurologic deficits that are seen in FASD.

Psychiatric comorbidity is also very common in ADHD, with estimates ranging from 40-80% of individuals with ADHD having a comorbid psychiatric condition (Barkley, 2006; Wilens, Biederman, & Spencer, 2002). Much like in FASD, the types of psychiatric comorbidities are vast, including externalizing, substance use, and internalizing problems. Regarding internalizing problems, it appears that anxiety and depression are somewhat common in ADHD. Specific estimates of prevalence of comorbid anxiety disorders have ranged from 10-50%, and estimates of comorbid...
depressive disorders have ranged from 10-32% (Barkley, 2006). Self-report measures of internalizing problems have been shown to be elevated in individuals with ADHD when compared to typically developing controls (Young & Gudjonsson, 2006). Examination of caregiver report of children with ADHD on the Psychological Discomfort scale of the PIC-2 standardization sample revealed elevations for the group (Lachar & Gruber, 2001). Overall it appears that a diagnosis of ADHD is a risk factor for internalizing problems that may manifest at levels significant enough to warrant comorbid anxiety and/or depressive disorder clinical diagnoses.

**Review of social withdrawal in FASD and ADHD.**

The Social Withdrawal clinical scale on the PIC-2 is a measure of a child’s willingness to engage in social activities. Elevations on this scale would describe children who are seen as shy and generally withdrawn from social activity. Evidence is lacking regarding the presence of social withdrawal in children with FASD. However, social withdrawal has been used in some descriptions of children with FASD, though excessive friendliness has also been used (Clark & Gibbard, 2003; O’Leary, 2004). Thus, it appears that more research is needed to elucidate the nature of social withdrawal in FASD.

Evidence of social withdrawal in children with FASD is also lacking. In fact, children with ADHD in the standardization sample of the PIC-2 were reported to have scores largely consistent with the test mean (Lachar & Gruber, 2001).

**Review of social skills deficits in FASD and ADHD.**

The Social Skills Deficits clinical scale on the PIC-2 is a measure of the quality and quantity of a child’s friendships. Children with elevations on this scale will typically
have few friends, have deficits in social skills, and not interact well with peers.

Caregivers of children with FASD often report deficits in social skills for children with FASD (Jirikowic et al., 2008). Social skills deficits have been identified as early as infancy in children with FASD, as measured by social engagement (Brown et al., 2010). Social skills deficits are consistently found in children with FASD, and appear to become more evident in adolescence as socialization becomes more complex and nuanced (Crocker et al., 2009). Communication deficits are also common in individuals with FASD, which likely contribute to socialization difficulties. Although most studies of social skills functioning in children with FASD have typically utilized caregiver and teacher report, a social problem solving task completed by adolescents with FASD showed more direct social skills deficits (McGee et al., 2008). Regarding quantity of friends, it is likely that children of elementary school age may be capable of maintaining superficial friendships, as children with FASD have been described as being excessively sociable and craving physical contact, which is likely tolerated by peers more at younger ages (O’Leary, 2004). However, it would be expected to see number of friends decline in adolescence due to more marked social skills deficits and decreased tolerance of inappropriate social behaviors by peers.

Socialization deficits are also characteristic of children with ADHD. Poor peer relationships and increased peers conflict are common for children with ADHD (Barkley, 2006). Peer status has also been shown to be reduced in children with ADHD, as desirability rankings by classroom peers are typically low for children with ADHD (Hodgens et al., 2000). Peer rejection has also been shown to be very common for children with ADHD (Hoza, 2007). Furthermore, caregiver reports of children with
ADHD typically show reported deficits in social skills functioning and communication (DeWolfe et al., 2000). Although difficulty with peer relationships has been shown to be at least partially attributable to the behavioral characteristics of children with ADHD, some research suggests that a stigma may be attached to the “ADHD” label by peers of children with ADHD. Specifically, peers of children with ADHD are more likely to treat children with ADHD badly, thus perpetuating a cycle of poor peer relationships (Hoza, 2007). Evidence also exist showing that children with ADHD are more likely to have a group of friends with disruptive behavior problems such as ADHD or oppositional behavior, thus reducing opportunities for vicarious learning of appropriate social behaviors from peers (Normand et al., 2010). Caregiver reports of social skills deficits in the PIC-2 standardization sample showed overall elevations on the scale with deficits more prevalent in the peer conflict subscale, than the peer status subscale (Lachar & Gruber, 2001).

Conclusions

Overall, there appear to be several commonalities between FASD and ADHD including CNS dysfunction as evidenced by abnormalities in structure and function, as well as deficits in cognitive and personality functioning. However, the magnitude of impairment is significantly greater in individuals with FASD. Furthermore, these also appear to be areas where the groups differ not only in level of impairment, but also in terms of the pattern of strengths and weaknesses inherent in the unique neurocognitive profile of each group. The high level of comorbidity argues for the need to find ways to differentiate the two groups in order to intervene in the most effective ways. Given the overwhelming evidence of CNS dysfunction for both groups, it would appear that this
would be the ideal place to start to differentiate the groups. Neuroimaging could be argued as an essential tool to be used in the differentiation of the groups given the rich use of neuroimaging in the current literature; however, there are several reasons that this is likely to not yield ideal results. First, the cost of neuroimaging would likely make clinical usage for diagnostic purposes prohibitive. Additionally, neuroimaging does little to quantify the level of impairment that can be expected. This is why neuropsychological testing is the ideal method for differentiating the groups, as it is most effective way to quantify functional impairment and evaluate the brain-behavior relationship.

Specifically, neuroimaging may show that structural and functional differences are present, but does not reveal exactly how these anomalies are going to affect cognitive, social, emotional, and behavioral functioning in the individual. Neuropsychological measures allow for a brain-behavior link to be made, and allow for quantifiable comparisons to be made to established norms, as well as to other clinical groups.

Although the present literature review compared and contrasted functioning in FASD and ADHD, few investigations have been conducted directly evaluating the groups in terms of neuropsychological functioning. Moreover, research attempting to differentiate the two groups on the basis of cognitive and personality functioning does not appear to exist in the current literature. The use of cognitive and personality variables to assist in identifying a neurocognitive profile for both FASD and ADHD would be a worthy endeavor given the ubiquity of these measures in school psychological and neuropsychological practice. Furthermore, investigations into how to best differentiate the groups using these measures would allow for more effective differential diagnosis, which currently would likely be difficult given the significant overlap in behavioral
manifestations in FASD and ADHD. Differentiating the groups when prenatal alcohol exposure is unknown would likely be an impossible task given the current state of the literature. Therefore, a need for research into identifying the best way to differentiate children with FASD and children with ADHD using common neuropsychological measures appears to be much needed.
CHAPTER III

Methodology

This chapter is organized into three sections: (1) Participant Selection/Procedures; (2) Instrumentation, Validity, and Reliability; and (3) Statistical Procedures and Data Analysis. The purpose of this chapter is to provide a detailed explanation of how the participants were selected and what procedures were utilized to collect and analyze the data.

Participant Selection/Procedures

This study was comprised of two groups of participants. One group of participants was comprised of children with a diagnosis of FASD with comorbid ADHD (FASD/ADHD). The second group of participants was children diagnosed with ADHD without FASD (ADHD). Exclusion criteria included diagnosis of mental retardation. The participants in the current study were drawn from an archival database derived from the patient files of a licensed, Ph.D.-level psychologist with a Health Service Provider in Psychology (HSPP) endorsement. The data were collected from the files of the psychologist by nine Ph.D. students in school psychology at Ball State University under
the supervision of a professor at Ball State University. Data collection took place between 10/2008 and 7/2010. The Ball State Institutional Review Board reviewed and approved the collection of the data used in this study. Patient files included the results of a comprehensive neuropsychological evaluation, including a diagnostic interview, neuropsychological testing, and an integrated report including diagnostic impressions. The neuropsychological exam included the *Wechsler Intelligence Scale for Children – Fourth Edition* (WISC-IV; Wechsler, 2003) and the *Personality Inventory for Children-Second Edition* (PIC-2; Lachar & Gruber, 2001), as well as other measures deemed necessary by the neuropsychologist.

All participants diagnosed with ADHD had the Combined subtype, indicating significant levels of inattention as well as hyperactivity and impulsivity. All children were diagnosed by a Ph.D.-level psychologist according to criteria outlined in the DSM-IV-TR. The diagnosis was made based on the diagnostic interview, observations, neuropsychological testing, and relevant rating scales.

All participants diagnosed with FASD were evaluated by a multidisciplinary team comprised of a licensed psychologist and a physician specializing in pediatrics and genetics. The psychologist and physician utilized the 4-Digit Diagnostic Code developed by the FAS Diagnostic and Prevention Network at the University of Washington (Astley & Clarren, 1999). This diagnostic system provides standardized and operationally defined guidelines for FASD diagnosis in 4 key areas by rating severity on a scale of 1 to 4. The 4 areas of assessment include:
1. Growth Deficiency: As evidenced by prenatal and postnatal growth measurements that have been adjusted for gender, age, and if possible parent height.

2. Facial Features and other physical findings: Specific areas of assessment include length of palpebral fissures, investigation of the philtrum for flatness, and investigation of thinness of the upper lip.

3. Brain Dysfunction: Brain function is investigated by examining the structure of the brain for anomalies and assessing for neurological disorders. Furthermore, psychometric measurements are used in the areas of Intelligence, Achievement, Adaptive Skills, Neuropsychological Functioning, and Language to assess for brain dysfunction. Caregiver reports of neuropsychological functioning can also be utilized.

4. Maternal Alcohol Use: This area is assessed by determining the amount of alcohol consumed by the mother during pregnancy, the duration of exposure, and the pattern of drinking (e.g. binge drinking).

Regarding participant selection, participants in the ADHD group were diagnosed with ADHD, Combined Type by the licensed psychologist according to DSM-IV-TR criteria and were not diagnosed with FASD. Participants in the FASD/ADHD group received an FASD diagnosis as a part of the multidisciplinary team consisting of the psychologist and the physician, and also received an ADHD, Combined Type diagnosis. FASD diagnoses included children with confirmed prenatal alcohol exposure, and evidence of dysfunction in one or more of the 3 remaining areas of assessment (i.e. Growth Deficiency, Facial
Features, and/or Brain Dysfunction). Participants in this group received diagnoses including Fetal Alcohol Syndrome, Fetal Alcohol Spectrum Disorder, Fetal Alcohol Effects, and Alcohol-Related Neurodevelopmental Disorder from the multidisciplinary team.

**Instrumentation**

**Wechsler Intelligence Scale for Children-Fourth Edition.**

The *Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV; Wechsler, 2003a) was administered to the participants of the current study. The WISC-IV is a measure of cognitive functioning and is used to evaluate children aged 6 years, 0 months through 16 years, 11 months. The WISC-IV provides a global composite measure of cognitive functioning (FSIQ) and four index scores (Verbal Comprehension; Perceptual Reasoning; Working Memory; Processing Speed). In addition to the composite measures, the WISC-IV contains 10 core subtests and five supplemental subtests. All 10 core subtests need to be administered to obtain the FSIQ and four index scales. The FSIQ and four index scales are reported as a standard score, with a mean of 100 and a standard deviation of 15. The subtests are reported as scaled scores, with a mean of 10 and a standard deviation of 3. The WISC-IV is a measure with good reliability, as evidenced by internal consistency reliability ranging from .81 to .97 for the composite indices on the WISC-IV (Sattler & Dumont, 2004). The WISC-IV appears to have good criterion validity as evidenced by high correlations between the WISC-IV and other measures of cognitive functioning, academic achievement, and adaptive behavior (Wechsler, 2003b). Additionally, the WISC-IV has been shown to have good construct validity as factor analytic studies have provided evidence that it is a good measure of
general intelligence and confirmed the utility of the four indices on the WISC-IV (Sattler & Dumont, 2004; Wechsler, 2003b).

**Verbal Comprehension Index.**

The Verbal Comprehension Index (VCI) is a measure of a child’s ability to reason, form concepts, and demonstrate acquired knowledge through verbal modalities (Wechsler, 2003b). The core subtests that comprise the VCI include Similarities, Vocabulary, and Comprehension. The Information and Word Reasoning subtests are supplemental and may be administered to acquire more information about the child or to substitute for the core subtests in the event of an invalid administration. The VCI has an overall average internal consistency reliability of .94 and a .93 stability coefficient (Wechsler, 2003b).

**Similarities.**

The Similarities subtest measures verbal concept formation and verbal abstract reasoning by asking the child to describe how two verbally-presented objects or concepts are similar. The Similarities subtest has an overall average internal consistency reliability of .86 and a .86 stability coefficient (Wechsler, 2003b).

**Vocabulary.**

The Vocabulary subtest measures the child’s word knowledge by asking for definitions of words. The Vocabulary subtest has been shown to have an overall average internal consistency reliability of .89 and a .92 stability coefficient (Wechsler, 2003b).

**Comprehension.**

The Comprehension subtest measures the child’s social judgment, verbal conceptualization, and verbal comprehension by asking questions about how to solve
social problems. The Comprehension subtest has been shown to have an overall average internal consistency reliability of .81 and a .82 stability coefficient (Wechsler, 2003b).

**Information.**

The Information subtest measures the child’s general fund of knowledge by asking questions about general knowledge topics. The Information subtest has an overall average internal consistency reliability of .86 and a .89 stability coefficient (Wechsler, 2003b).

**Word Reasoning.**

The Word Reasoning subtest measures the child’s ability to use analogical reasoning, verbal abstraction, and to integrate and synthesize information by asking the child to identify the concept that is present in a series of clues. The Word Reasoning subtest has an overall average internal consistency reliability of .80 and a .82 stability coefficient (Wechsler, 2003b).

**Perceptual Reasoning Index.**

The Perceptual Reasoning Index (PRI) is a measure of a child’s fluid reasoning, visual-spatial processing, and visual-spatial concept formation (Wechsler, 2003b). The core subtests that comprise the PRI include Block Design, Picture Concepts, and Matrix Reasoning. The Picture Completion subtest is supplemental and may be administered to acquire more information about the child or to substitute for the core subtests in the event of an invalid administration. The PRI has been shown to have an overall average internal consistency reliability of .92 and a .89 stability coefficient (Wechsler, 2003b).
Block Design.

The Block Design subtest measures the child’s ability to form a visual gestalt through the analysis and synthesis of visual stimuli by asking the child to use blocks to replicate a visually-presented design under time constraints. The Block Design subtest has an overall average internal consistency reliability of .86 and a .82 stability coefficient (Wechsler, 2003b).

Picture Concepts.

The Picture Concepts subtest measures the child’s ability to categorize and use abstract reasoning with visual information by asking the child to choose pictures from a series of rows that share a common characteristic. The Picture Concepts subtest has an overall average internal consistency reliability of .82 a .76 stability coefficient (Wechsler, 2003b).

Matrix Reasoning.

The Matrix Reasoning subtest measures the child’s fluid reasoning ability and ability to form visual concepts by asking the child to select an appropriate response to correctly complete an incomplete matrix. The Matrix Reasoning subtest has an overall average internal consistency reliability of .89 and a .85 stability coefficient (Wechsler, 2003b).

Picture Completion.

The Picture Completion subtest measures the child’s visual processing and discrimination abilities by asking the child to identify the important part missing from a picture. The Picture Completion subtest has an overall average internal consistency reliability of .84 and a .84 stability coefficient (Wechsler, 2003b).
Working Memory Index.

The Working Memory Index (WMI) is a measure of a child’s auditory attention and working memory abilities (Wechsler, 2003b). The core subtests that comprise the WMI include the Digit Span and Letter-Number Sequencing subtests. The Arithmetic subtest is supplemental and may be administered to acquire more information about the child or to substitute for the core subtests in the event of an invalid administration. The WMI has an overall average internal consistency reliability of .92 and a .89 stability coefficient (Wechsler, 2003b).

Digit Span.

The Digit Span subtest measures the child’s immediate memory, rote recall skills, and auditory working memory by asking the child to repeat numbers in the same order as the examiner in the Digits Forward section, and repeat the numbers in reverse order in the Digits Backward section. The Digit Span subtest has an overall average internal consistency reliability of .87 and a .83 stability coefficient (Wechsler, 2003b).

Letter-Number Sequencing.

The Letter-Number Sequencing subtest measures the child’s auditory working memory by asking the child to recall a sequence of verbally-presented numbers and letters with the numbers in ascending order and the letters in alphabetical order. The Letter-Number Sequencing subtest has an overall average internal consistency reliability of .90 and a .83 stability coefficient (Wechsler, 2003b).

Arithmetic.

The Arithmetic subtest measures the child’s number reasoning ability and mental manipulation skills by asking the child to solve a verbally-presented arithmetic problem
under time constraints. The Arithmetic subtest has an overall average internal consistency reliability of .88 and a .79 stability coefficient (Wechsler, 2003b).

**Processing Speed Index.**

The Processing Speed Index (PSI) is a measure of a child’s ability to visually examine, order, and discriminate simple visual information (Wechsler, 2003b). The core subtests that comprise the PSI include the Coding and Symbol Search subtests. The Cancellation subtest is supplemental and may be administered to acquire more information about the child or to substitute for the core subtests in the event of an invalid administration. The PSI has been shown to have an overall average internal consistency reliability of .88 and .86 stability coefficient (Wechsler, 2003b).

**Coding.**

The Coding subtest measures the child’s processing speed, learning ability, visual attention, and perceptual motor skills by asking the child to copy symbols that are paired with specific geometric shapes. The Coding subtest has an overall average internal consistency reliability of .85 and a .84 stability coefficient (Wechsler, 2003b).

**Symbol Search.**

The Symbol Search subtest measures the child’s processing speed, short-term memory, and visual perception abilities by asking the child to scan a group of symbols and decide if the target symbol matches and of the symbols in the match group. The Symbol Search subtest has been shown to have an overall average internal consistency reliability of .79 and a .80 stability coefficient (Wechsler, 2003b).
Cancellation.

The Cancellation subtest measures the child’s processing speed, vigilance and selective attention by asking the child to scan an arrangement of pictures and mark pictures that meet certain criteria. The Cancellation subtest has been shown to have adequate reliability as evidenced by an overall average internal consistency reliability of .79 and a .79 stability coefficient (Wechsler, 2003b).

Personality Inventory for Children-Second Edition

The Personality Inventory for Children-Second Edition (PIC-2) was completed by the caregivers of all of the participants in the current study (Lachar & Gruber, 2001). The PIC-2 is a caregiver completed rating scale of behavioral, emotional, and social adjustment and is used to evaluate children aged 5 years, 0 months through 19 years, 11 months. The PIC-2 provides three response validity scales (Inconsistency; Dissimulation; and Defensiveness) and nine adjustment scales (Cognitive Impairment; Impulsivity and Distractibility; Delinquency; Family Dysfunction; Reality Distortion; Somatic Concern; Psychological Discomfort; Social Withdrawal; and Social Skills Deficits). In addition to the adjustment scales, the PIC-2 contains 21 subscales to the adjustment scales. The response validity scales, adjustment scales, and adjustment subscales are reported as T-scores, with a mean of 50 and a standard deviation of 10. The PIC-2 is a measure with good reliability as evidenced by internal consistency alphas ranging from .75 to .91 for the adjustment scales (Lachar & Gruber, 2001). The criterion validity of the PIC-2 also appears to be satisfactory as evidenced by high correlations between PIC-2 results and independent reports of the children’s behavior by clinicians, teachers, and child self-report (Lachar & Gruber, 2001). Content validity of the PIC-2 is
substantiated by careful consideration of the language used in the PIC-2, including revision of outdated terms and removal of double negative statements. Additional support for content validity is demonstrated by careful examination of the factor structure of the adjustment scales (Lachar & Gruber, 2001).

**Inconsistency Scale.**

The Inconsistency scale measures the validity of the response pattern by examining if the caregiver comprehended the rating scale and if proper attention was given when responding. The Inconsistency scale is comprised of item pairs that are expected to receive matching or opposite responses by the caregiver. T-scores above 70 indicate that the results should be interpreted with caution due to an inconsistent response pattern. The Inconsistency scale has been shown to have an internal consistency reliability of .68 and a .74 stability coefficient (Lachar & Gruber, 2001).

**Dissimulation Scale.**

The Dissimulation scale measures the validity of the response pattern by examining if the caregiver exaggerated or feigned symptoms. The Dissimulation scale is comprised of items that were frequently endorsed by caregivers who were asked to respond as if they were malingering. T-scores above 70 indicate that the results should be interpreted with caution due to a tendency to exaggerate symptoms. T-scores 90 and above are indicative of an invalid response pattern. The Dissimulation scale has an internal consistency reliability of .80 and a .77 stability coefficient (Lachar & Gruber, 2001).
Defensiveness Scale.

The Defensiveness scale measures the validity of the response pattern by examining if the caregiver presented the child in an overly favorable light. The Defensiveness scale is comprised of items that are implausibly positive or represent a denial of common childhood and adolescent negative behaviors. T-scores above 60 indicate that the results should be interpreted with caution due to the possibility that the caregiver denied or minimized symptoms. The Defensiveness scale has been shown to have an internal consistency reliability of .86 and a .80 stability coefficient (Lachar & Gruber, 2001).

Cognitive Impairment Adjustment Scale.

The Cognitive Impairment Adjustment Scale provides an estimate of cognitive functioning, with elevations suggesting a cognitive evaluation may be needed. Elevations on this scale are related to cognitive functioning one or more standard deviations below the population mean. Additionally, corresponding deficits in academic achievement and adaptive skills functioning can be expected. The Cognitive Impairment Adjustment scale is divided into three subscales including the Inadequate Abilities, Poor Achievement, and Developmental Delay subscales. The Cognitive Impairment Adjustment scale has been shown to have an internal consistency reliability of .84 and a .89 stability coefficient (Lachar & Gruber, 2001).

Inadequate Abilities.

Elevations on the Inadequate Abilities subscale suggest deficits in intellectual functioning. The Inadequate Abilities subscale has been shown to have an internal consistency reliability of .72 and a .87 stability coefficient (Lachar & Gruber, 2001).
Poor Achievement.

Elevations of the Poor Achievement subscale suggest poor school adjustment, including lack of enjoyment of school and lack of engagement in academic tasks. The Poor Achievement subscale has been shown to have an internal consistency reliability of .75 and a .81 stability coefficient (Lachar & Gruber, 2001).

Developmental Delay.

Elevations on the Developmental Delay subscale suggest delayed acquisition of developmental milestones. The Developmental Delay subscale has an internal consistency reliability of .66 and a .76 stability coefficient (Lachar & Gruber, 2001).

Impulsivity and Distractibility Adjustment Scale.

The Impulsivity and Distractibility Adjustment Scale is a measure of caregiver reported externalizing behaviors that are characteristic of ADHD, including impulsivity, hyperactivity, and disruptive behaviors. Elevations on this scale are related to conduct problems, hyperactivity, and impulsivity. The Impulsivity and Distractibility Adjustment scale is divided into two subscales including the Disruptive Behavior and Fearlessness subscales. The Impulsivity and Distractibility Adjustment scale has been shown to have an internal consistency reliability of .87 and a .88 stability coefficient (Lachar & Gruber, 2001).

Disruptive Behavior.

Elevations on the Disruptive Behavior subscale suggest increased problem behaviors, externalizing problems, and dysregulation of emotions. The Disruptive Behavior subscale has been shown to have an internal consistency reliability of .86 and a .87 stability coefficient (Lachar & Gruber, 2001).
Fearlessness.

Elevations on the Fearlessness subscale suggest increased disobedience and increased aggressive peer interactions. The Fearlessness subscale has an internal consistency reliability of .49 and a .83 stability coefficient (Lachar & Gruber, 2001).

Delinquency Adjustment Scale.

The Delinquency Adjustment Scale is a measure of antisocial behavior, modulation of behavior and emotions, and noncompliance. Elevations on this scale are related to poor modulation of anger and increased problematic behaviors. The Delinquency Adjustment scale is divided into three subscales including the Antisocial Behavior, Dyscontrol, and Noncompliance subscales. The Delinquency Adjustment scale has been shown to have an internal consistency reliability of .91 and a .75 stability coefficient (Lachar & Gruber, 2001).

Antisocial Behavior.

Elevations on the Antisocial Behavior subscale suggest increased disobedience, conduct problems, and possible drug and alcohol abuse. The Antisocial Behavior subscale has an internal consistency reliability of .77 and a .66 stability coefficient (Lachar & Gruber, 2001).

Dyscontrol.

Elevations on the Dyscontrol subscale suggest increased difficulty with anger modulation and emotional lability. The Dyscontrol subscale has been shown to have an internal consistency reliability of .83 and a .72 stability coefficient (Lachar & Gruber, 2001).
**Noncompliance.**

Elevations on the Noncompliance subscale suggest increased rule-breaking and disruptive behavior. The Noncompliance subscale has been shown to have an internal consistency reliability of .86 and a .77 stability coefficient (Lachar & Gruber, 2001).

**Family Dysfunction Adjustment Scale.**

The Family Dysfunction Adjustment Scale is a measure of problematic family interactions. Elevations on this scale are related to parent divorce, conflict between parents, and a lack of enjoyment when family members spend time together. The Family Dysfunction Adjustment scale is divided into two subscales including the Conflict Among Members and Parent Maladjustment subscales. The Family Dysfunction Adjustment scale has been shown to have an internal consistency reliability of .86 and a .90 stability coefficient (Lachar & Gruber, 2001).

**Conflict Among Members.**

Elevations on the Conflict Among Members subscale suggest discord among family members. The Noncompliance subscale has been shown to have an internal consistency reliability of .81 and a .86 stability coefficient (Lachar & Gruber, 2001).

**Parent Maladjustment.**

Elevations on the Parent Maladjustment subscale suggest strained relationships between parents, and possible signs of parent maladjustment. The Parent Maladjustment subscale has been shown to have an internal consistency reliability of .74 and a .87 stability coefficient (Lachar & Gruber, 2001).
**Reality Distortion Adjustment Scale.**

The Reality Distortion Adjustment Scale is a measure of the extent of disability present in the child. Elevations on this scale suggest emotional lability and significant deficits in adaptive functioning. The Delinquency Adjustment scale is divided into two subscales including the Developmental Deviation and Hallucinations and Delusions subscales. The Delinquency Adjustment scale has been shown to have an internal consistency reliability of .83 and a .66 stability coefficient.

**Developmental Deviation.**

Elevations on the Developmental Deviation subscale suggest impaired adaptive functioning, academic achievement, and cognitive functioning. The Developmental Deviation subscale has been shown to have an internal consistency reliability of .73 and a .67 stability coefficient (Lachar & Gruber, 2001).

**Hallucinations and Delusions.**

Elevations on the Hallucinations and Delusions subscale suggest likely impaired reality testing and possible psychotic symptoms. The Hallucinations and Delusions subscale has an internal consistency reliability of .73 and a .63 stability coefficient (Lachar & Gruber, 2001).

**Somatic Concerns Adjustment Scale.**

The Somatic Concerns Adjustment Scale is a measure of health concerns and internal physical feelings. Elevations on this scale suggest a tendency to convert stress into physical symptoms. The Somatic Concerns Adjustment scale is divided into two subscales including the Psychosomatic Preoccupation and Muscular Tension and Anxiety
subscales. The Somatic Concerns Adjustment scale has been shown to have an internal consistency reliability of .79 and a .74 stability coefficient.

*Psychosomatic Preoccupation.*

Elevations on the Psychosomatic Preoccupation subscale suggest the child is concerned about his/her health and makes frequent trips to the doctor. The Psychosomatic Preoccupation subscale has been shown to have an internal consistency reliability of .73 and a .66 stability coefficient (Lachar & Gruber, 2001).

*Muscular Tension and Anxiety.*

Elevations on the Muscular Tension and Anxiety subscale suggest health complaints by the child and may be associated with unusual physical responses, such as blurred vision and facial twitching. The Muscular Tension and Anxiety subscale has an internal consistency reliability of .61 and a .85 stability coefficient (Lachar & Gruber, 2001).

*Psychological Discomfort Adjustment Scale.*

The Psychological Discomfort Adjustment Scale is a measure of negative affect. Elevations on this scale suggest increased irritability, emotional lability, and internalizing problems. The Somatic Concerns Adjustment scale is divided into three subscales including the Fear and Worry, Depression, and Sleep Disturbances/Preoccupation with Death subscales. The Psychological Discomfort Adjustment scale has an internal consistency reliability of .84 and a .83 stability coefficient.
Fear and Worry.

Elevations on the Fear and Worry subscale suggest uncertainty in the child, as well as nervousness and anxiety. The Fear and Worry subscale has an internal consistency reliability of .61 and a .80 stability coefficient (Lachar & Gruber, 2001).

Depression.

Elevations on the Depression subscale suggest signs of depressive symptomatology including irritability, hopelessness, low self-esteem, depressed mood, and possible suicidal ideation. The Depression subscale has an internal consistency reliability of .79 and a .79 stability coefficient (Lachar & Gruber, 2001).

Sleep Disturbances/Preoccupation with Death.

Elevations on the Sleep Disturbances/Preoccupation with Death subscale suggest sleep problems, with higher elevations suggestive of suicidal thoughts, threats, and attempts. The Sleep Disturbances/Preoccupation with Death subscale has an internal consistency reliability of .61 and a .82 stability coefficient (Lachar & Gruber, 2001).

Social Withdrawal Adjustment Scale.

The Social Withdrawal Adjustment Scale is a measure of timidity and social withdrawal. The Social Withdrawal Adjustment scale is divided into two subscales including the Social Introversion and Isolation subscales. Social Withdrawal Adjustment scale has an internal consistency reliability of .75 and a .74 stability coefficient.

Social Introversion.

Elevations on the Social Introversion subscale suggest avoidance of interpersonal interactions and increased worry about social interactions. The Social Introversion
subscale has an internal consistency reliability of .74 and a .76 stability coefficient (Lachar & Gruber, 2001).

Isolation.

Elevations on the Isolation subscale suggest social avoidance and isolation. The Isolation subscale has an internal consistency reliability of .55 and a .70 stability coefficient (Lachar & Gruber, 2001).

Social Skills Deficits Adjustment Scale.

The Social Skills Deficits Adjustment Scale is a measure of the quality and quantity of friendships of the child. The Social Skills Deficits Adjustment scale is divided into two subscales including the Limited Peer Status and Conflict with Peers subscales. Social Skills Deficits Adjustment scale has an internal consistency reliability of .85 and a .82 stability coefficient.

Limited Peer Status.

Elevations on the Limited Peer Status subscale suggest decreased peer influence and lack of popularity. The Limited Peer Status subscale has an internal consistency reliability of .79 and a .77 stability coefficient (Lachar & Gruber, 2001).

Conflict with Peers.

Elevations on the Conflict with Peers subscale suggest difficulty making and keeping friends. The Conflict with Peers subscale has been shown to have an internal consistency reliability of .79 and a .85 stability coefficient (Lachar & Gruber, 2001).

Statistical Procedures and Data Analysis

Data analyses were used to answer the 10 research questions, which pertain to cognitive and personality functioning in children with FASD/ADHD and children with
ADHD. The first analyses used are correlation analyses. Specifically, correlation matrices were constructed and canonical correlation analyses were run. Given the multiple subtests and adjustment scale scores that were used to investigate the research questions, Multivariate Analysis of Variance (MANOVA) and Descriptive Discriminant Analysis (DDA) were also used to analyze the data. Furthermore, a Classification and Regression Tree was conducted to determine the best cognitive and personality predictors of group membership into the FASD/ADHD or ADHD groups. The specific statistical procedures used to answer the eight research questions are outlined below.

**What is the relationship between the WISC-IV and the PIC-2 for the children with FASD/ADHD?**

In order to investigate the strength and nature of the relationship between the WISC-IV and the PIC-2 variables for the children with FASD/ADHD, a correlation matrix was constructed and a canonical correlation analysis was run. Specifically, for the correlation matrix the Pearson’s correlation coefficient was reported for the correlation between each of the WISC-IV subtests and the PIC-2 adjustment scales. For the canonical correlation, the WISC-IV subtests were placed in one set of variables and the PIC-2 adjustment scales were placed in the second set of variables.

**What is the relationship between the WISC-IV and the PIC-2 for the children with ADHD?**

In order to investigate the relationship between the WISC-IV and the PIC-2 variables for the children with ADHD, a correlation matrix was constructed and a canonical correlation analysis was run.
What is the WISC-IV profile of children with FASD/ADHD and children with ADHD?

In order to investigate the cognitive profiles of children with FASD/ADHD and children with ADHD, descriptive statistics were used, including group means on measures of cognitive functioning. The specific measures included to answer this research question were scores from 11 WISC-IV subtests.

Are there significant cognitive differences between children with FASD/ADHD and children with ADHD as measured by the subtest scores on the WISC-IV?

The goal of investigating group differences in cognitive functioning was accomplished through the use of Multivariate Analysis of Variance (MANOVA), which is a statistical analysis that allows for the testing for a difference between groups across several dependent variables concurrently (Field, 2005). Specifically, the FASD/ADHD and ADHD groups were used as the independent variables and the WISC-IV subtest scores were used as the dependent variables. The specific subtests used in the analysis were the Block Design, Similarities, Digit Span, Picture Concepts, Coding, Vocabulary, Letter-Number Sequencing, Matrix Reasoning, Comprehension, Symbol Search, and Information subtests.
What is the profile of adjustment scales on the PIC-2 for children with FASD/ADHD and for children with ADHD?

The goal of investigating the personality profile of children with FASD/ADHD and children with ADHD was addressed by reporting the PIC-2 adjustment scale group means for the FASD/ADHD group and the ADHD group.

Are there significant personality differences between children with FASD/ADHD and ADHD as measured by the PIC-2 adjustment scales?

The examination of group differences in personality was accomplished through the use of MANOVA. Specifically, the FASD/ADHD and ADHD groups were used as the independent variables and the PIC-2 adjustment scales were used as the dependent variables. The specific adjustment scales used in the analysis were the Cognitive Impairment, Impulsivity and Distractibility, Delinquency, Family Dysfunction, Reality Distortion, Somatic Concern, Psychological Discomfort, Social Withdrawal, and Social Skills Deficits adjustment scales.

What cognitive variables best differentiate the FASD/ADHD and ADHD groups?

The goal of best differentiating the FASD/ADHD and ADHD groups by utilizing performance on measures of cognitive functioning was accomplished through the use of Descriptive Discriminant Analysis (DDA). In particular, to investigate how to best differentiate the groups based on cognitive variables, a DDA was run as a follow-up to the MANOVA that utilized the WISC-IV subtest scores. This allowed for analysis of which WISC-IV variables were the most important contributors to group differences by
identifying combinations of variables that significantly differentiate the groups (Field, 2005).

**What personality variables best differentiate the FASD/ADHD and ADHD groups?**

The goal of best differentiating the FASD/ADHD and ADHD only groups on measures of personality functioning was accomplished by the use of DDA as a follow-up procedure to a significant MANOVA using the PIC-2 adjustment scale scores. This allowed for analysis of which PIC-2 variables were most important for group differences in personality functioning.

**What are the specific WISC-IV subtests that most likely classify a diagnosis of FASD/ADHD or ADHD?**

The goal of assessing the best cognitive predictors of group membership into the FASD/ADHD or ADHD groups was accomplished by using a Classification and Regression Tree (CART) analysis.

**What are the specific PIC-2 adjustment scales that most likely classify a diagnosis of FASD/ADHD or ADHD?**

The goal of assessing the best personality predictors of group membership into the FASD/ADHD or ADHD groups was also accomplished by using a CART analysis.
CHAPTER IV

Results

This chapter will present the results of various statistical analyses. It is divided into six sections: (1) description of the sample; (2) results of the Canonical Correlation analyses; (3) results of the Multivariate Analysis of Variance tests; (4) results of the Descriptive Discriminant Analysis tests; (5) results of the Classification and Regression Trees; and (6) Conclusions.

Description of the Sample

The current study was comprised of 67 children with comorbid FASD and ADHD (FASD/ADHD) and 115 children with ADHD without FASD (henceforth referred to as children with ADHD) who were administered the WISC-IV and the PIC-2. The sample utilized in the current study excluded participants diagnosed with mental retardation. Table 4.1 contains descriptive statistics for the demographic information of the participants.
The sample of children with FASD/ADHD consisted of 67 participants, with 38 males (57%) and 29 females (43%). The average age of the FASD/ADHD group was 9.68 years with a standard deviation of 2.7. The sample of children with ADHD consisted of 115 participants, with 80 males (70%) and 35 females (30%). The average age of the ADHD group was 10.05 with a standard deviation of 2.95.

**Correlation Analyses**

**Correlation Matrices**

Two correlation matrices and two canonical correlation analyses were used in the current study to investigate the relationship between the WISC-IV and the PIC-2 variables for the two groups in the study, the FASD/ADHD group and the ADHD group. Table 4.2 contains the Pearson correlation coefficients among the target variables for the children with FASD/ADHD and the children with ADHD.
Correlation Analysis for the FASD/ADHD sample and the ADHD sample

<table>
<thead>
<tr>
<th></th>
<th>Cog Imp</th>
<th>Imp &amp; Dist</th>
<th>Del</th>
<th>Fam Dys</th>
<th>Reality Dis</th>
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<td>.107/</td>
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<td>.198**</td>
<td>.174</td>
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<td>-.162/</td>
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<td>.174/</td>
<td>.071/</td>
<td>.115/</td>
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<tr>
<td></td>
<td>.227*</td>
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<td>.120</td>
<td>.033</td>
<td>.043</td>
<td>-.047</td>
<td></td>
</tr>
</tbody>
</table>

Note: Within each cell the correlation coefficient for the FASD/ADHD group is to the left of the /, and the coefficients for the ADHD group are below the /.

* Significant at the .05 level
** Significant at the .001

BD=Block Design, Sim=Similarities, DS=Digit Span, PC=Picture Concepts, Cod=Coding, Voc=Vocabulary, LNS=Letter-Number

The results reveal significant relationships between the Cognitive Impairment adjustment scale from the PIC-2 and several of the WISC-IV subtests for the FASD/ADHD group. Specifically, there were statistically significant correlations between the Cognitive Impairment adjustment scale from the PIC-2 and the Block Design, Similarities, Digit Span, Vocabulary, Matrix Reasoning, and Information subtests.
from the WISC-IV. There was also a significant correlation between the Psychological Discomfort adjustment scale and the Coding subtest for the FASD/ADHD group. Overall, however, there were few significant correlations between the PIC-2 scales and the WISC-IV subtests in the FASD/ADHD group.

A similar pattern of results emerged with the ADHD group. Specifically, the Cognitive Impairment adjustment scale was correlated significantly with several WISC-IV subtests, including Similarities, Picture Concepts, Coding, and Information. However, there were some differences present as well. Specifically, there were large differences between the groups in the correlations between the Cognitive Impairment adjustment scale and the Block Design, Vocabulary, and Matrix Reasoning subtests, with the FASD/ADHD group having higher correlation coefficients. The Picture Concepts and Comprehension subtests were also significantly correlated with the Impulsivity and Distractibility adjustment scale for the ADHD group. Furthermore, significant correlations were present among the Psychological Discomfort scale and the Block Design subtest and between the Social Withdrawal scale and the Letter-Number Sequencing subtests. However, much like with the FASD/ADHD group, the majority of the correlations between the PIC-2 scales and the WISC-IV subtests were not significant.

**Canonical Correlations**

Canonical correlation is a statistical analysis that allows for the relationship between two sets of variables to be analyzed by combining each set of variables into a linear equation with different weights applied to each of the variables to maximize the correlation between the two variables sets, which forms a canonical variable. However, given that there are multiple variables in each set, there can be multiple canonical
variables. Specifically, there can be as many canonical variables as there are variables in
the smallest set, though it is common for only the first two to three variables to be
significant is statistical significance is achieved (Tabachnick & Fidell, 2007).

The results of the first canonical correlation analysis, which utilized the WISC-IV
subtests and the PIC-2 adjustment scales for the FASD/ADHD group, revealed no
statistically significant canonical correlations between the two sets of variables. These
results suggest that there is not a statistically significant relationship between the two sets
of variables, which in the current analysis was the WISC-IV subtests and the PIC-2
adjustment scales. The results of the second canonical correlation analysis, which
examined the relationship between the WISC-IV subtests and the PIC-2 adjustment
scales for the ADHD group, also resulted in no statistically significant canonical
correlation. In sum, the results of the canonical correlation analyses for these two clinical
groups indicated that the set of PIC-2 variables and the set of WISC-IV variables are
largely unrelated.

**Multivariate Analysis of Variance**

Two Multivariate Analyses of Variance (MANOVA) were used in the current
study to investigate cognitive and personality differences between the FASD/ADHD
group and the ADHD group. These differences were investigated using the subtests from
the WISC-IV and the adjustment scales from the PIC-2. The dependent variables utilized
in the MANOVAs in this study included 11 subtests from the WISC-IV and nine
adjustment scales from the PIC-2. The independent variables were the FASD/ADHD and
ADHD groups.
Assumptions of MANOVA Statistical Tests

The assumptions of MANOVA include independence of the observations, random sampling, multivariate normality, and homogeneity of the covariance matrices across groups. The assumption of independence was met, as each participant was individually evaluated by a licensed psychologist without influence from other participants in the current study. The assumption of random sampling was violated because the current sample was taken from a clinically-referred population from a Midwestern city.

The assumption of multivariate normality was assessed with Mardia’s test as seen in Table 4.3.

Table 4.3
Results of Mardia’s Tests

<table>
<thead>
<tr>
<th></th>
<th>WISC-IV Sample</th>
<th>PIC-2 Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Observations</td>
<td>182</td>
<td>182</td>
</tr>
<tr>
<td>Number of Variables</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Skew (p)</td>
<td>5993.24 (&lt;0.001)</td>
<td>282.44 (&lt;0.001)</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>79.8 (&lt;0.001)</td>
<td>-0.11 (0.91)</td>
</tr>
</tbody>
</table>

Note: P-values shown in parentheses

The results of Mardia’s test in both MANOVAs indicate the assumption of multivariate normality may have been violated as statistically significant levels of skewness and kurtosis were present for the WISC-IV MANOVA. The results of the PIC-2 MANOVA show statistically significant levels of skewness. Although the results of Mardia’s test indicate that the assumption of multivariate normality may have been violated, it should be noted that MANOVA has been shown to be robust to this violation. This robustness is especially true when the size of the sample is greater than 40 and there are more than 10 participants in each group, which is present in the current sample (Tabachnick & Fidell, 2007).
The assumption of homogeneity of the covariance matrices across groups was tested using the Box’s M test. The results of Box’s M for the WISC-IV subtests and the PIC-2 adjustment scales can be seen in Table 4.4.

Table 4.4.

*Box’s M Test of Variance-Covariance*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISC-IV</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>PIC-2</td>
<td>.805</td>
</tr>
</tbody>
</table>

Note: * indicates rejection of the null hypothesis.

The results of the Box’s M tests show that the assumption of homogeneity of the covariance matrices is met for the PIC-2 MANOVA; however, this assumption was not met for the WISC-IV MANOVA. Given that this assumption was violated for the WISC-IV MANOVA, a robust analysis was conducted to determine if significant results were present. Specifically, Yao’s test was utilized as it has been shown to be robust to violations of multivariate normality and homogeneity of the covariance matrix violations (Algina, Oshima, & Tang, 1991; Yao, 1965).

**MANOVA Results**

Analyses of cognitive and personality differences between children with FASD/ADHD and ADHD on the WISC-IV subtests and the PIC-2 adjustment scales were conducted using two MANOVAs. Two separate MANOVAs were used due to the dissimilarity between the two sets of dependent variables, as evidenced by the lack of statistical significance in the canonical correlation analyses that were described above. This level of dissimilarity suggested that two separate MANOVAs should be used as the power of MANOVA is reduced as the relationship between the dependent variables decreases (Tabachnick & Fidell, 2007). The first MANOVA examined group
differences on the WISC-IV subtests. The Yao test statistic was used to interpret if the results of the analysis were significant, as it has been shown to be robust to the violation of the assumption of homogeneity of the covariance matrices across groups (Algina, Oshima, & Tang, 1991; Yao, 1965). Table 4.5 shows the results of the MANOVA utilizing the WISC-IV subtests as dependent variables.

Table 4.5

MANOVA Results for WISC-IV Subtests

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Yao’s statistic</th>
<th>F Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic Group</td>
<td>26.6068</td>
<td>2.2670</td>
<td>0.0139</td>
</tr>
</tbody>
</table>

The MANOVA utilizing the WISC-IV subtests was statistically significant using the Yao test statistic (F=2.2670; p=0.0139), indicating that there are significant differences between children with FASD/ADHD and children with ADHD in terms of cognitive functioning on the selected WISC-IV subtests.

The second MANOVA examined group differences on the PIC-2 adjustment scales. For this MANOVA, the Pillai’s Trace statistic was used to determine significance in the PIC-2 MANOVA because it has been shown to be more robust to nonnormality than other test statistics, especially for smaller sample sizes and in samples with unequal participants across groups (Tabachnick & Fidell, 2007). Table 4.6 shows the results of the MANOVA utilizing the PIC-2 adjustment scales as dependent variables.

Table 4.6

MANOVA Results for PIC-2 Adjustment Scales

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Pillai’s Trace</th>
<th>F Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic Group</td>
<td>.159</td>
<td>3.618</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
The MANOVA using the PIC-2 adjustment scales was also statistically significant (F=3.618; p<0.001), indicating that there are significant group differences in terms of personality functioning as measured by the adjustment scales on the PIC-2.

**Descriptive Discriminant Analysis (DDA)**

Given that the results of both MANOVAs were significant, follow-up DDAs were conducted to identify which of the WISC-IV subtests and PIC-2 adjustment scales contributed most to differences between the FASD/ADHD group and the group with ADHD. DDA works by finding weighted combinations of the dependent variables that maximally differentiate the groups, thus providing one or more such linear combinations, or discriminant functions. Statistically significant discriminant functions represent a linear combination of predictor variables that provide useful information about differences in the groups (Finch, 2010). In the current study, two separate follow-up DDAs were run, with one DDA utilizing the WISC-IV subtests as predictors and the second DDA using the PIC-2 adjustment scales as predictors.

The structure coefficients were analyzed in each DDA to determine the contribution of each predictor variable in the group differences. The structure coefficients represent the correlation between the individual predictor variable and the discriminant function. Larger structure coefficients are indicative of a closer relationship to the discriminant function. Therefore, larger structure coefficients can be viewed as being of greater importance in contributing to overall group differences (Finch, 2010). General convention holds that individual correlations exceeding .300 can be interpreted as contributing appreciably to group separation (Tabachnick & Fidell, 2007). The
structure coefficients for the WISC-IV predictors and the PIC-2 predictors can be found
in Table 4.7.

Table 4.7.

*Structure Matrix for the WISC-IV Subtests and PIC-2 Adjustment Scales*

<table>
<thead>
<tr>
<th>WISC-IV Subtests</th>
<th>Structure Coefficients</th>
<th>PIC-2 Adjustment Scales</th>
<th>Structure Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td>.679*</td>
<td>Cognitive Impairment</td>
<td>-.573*</td>
</tr>
<tr>
<td>Picture Concepts</td>
<td>.556*</td>
<td>Somatic Concern</td>
<td>.568*</td>
</tr>
<tr>
<td>Information</td>
<td>.519*</td>
<td>Family Dysfunction</td>
<td>.407*</td>
</tr>
<tr>
<td>Matrix Reasoning</td>
<td>.483*</td>
<td>Delinquency</td>
<td>.288</td>
</tr>
<tr>
<td>Letter-Number</td>
<td>.323*</td>
<td>Psychological Discomfort</td>
<td>.239</td>
</tr>
<tr>
<td>Sequencing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coding</td>
<td>.298</td>
<td>Social Skills Deficits</td>
<td>-.157</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.264</td>
<td>Social Withdrawal</td>
<td>.123</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.190</td>
<td>Impulsivity/Distractibility</td>
<td>.120</td>
</tr>
<tr>
<td>Symbol Search</td>
<td>.188</td>
<td>Reality Distortion</td>
<td>.056</td>
</tr>
<tr>
<td>Block Design</td>
<td>.123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similarities</td>
<td>.102</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = greater than .300.

The results of the significant DDA utilizing the WISC-IV subtests reveal that the
most important predictor variable in determining group differences between the children
with FASD/ADHD and children with ADHD was the Comprehension subtest. Although
the Comprehension subtest was the most important predictor of group separation, the
Picture Concepts, Information, Matrix Reasoning, and Letter-Number Sequencing
subtests were also important predictors, based on the .300 cut value. The results of the
significant DDA using the PIC-2 adjustment scales also revealed unique predictors of
group differences. The most important predictor was the Cognitive Impairment
adjustment scale, followed closely by the Somatic Concern adjustment scale. The Family
Dysfunction adjustment scale was also shown to be an important predictor variable.

Table 4.8 contains the means and standard deviations for each of the predictor
variables from the WISC-IV subtests and the PIC-2 adjustment scales.
Table 4.8

Mean (Standard Deviation) for the WISC-IV Subtests and PIC-2 Adjustment Scales

<table>
<thead>
<tr>
<th>WISC-IV Subtest</th>
<th>ADHD</th>
<th>FASD/ADHD</th>
<th>PIC-2 Adjustment Scale</th>
<th>ADHD</th>
<th>FASD/ADHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Design</td>
<td>8.4 (2.75)</td>
<td>8.13 (3.02)</td>
<td>Cognitive Impairment</td>
<td>69.99 (11.21)</td>
<td>75.94 (12.18)</td>
</tr>
<tr>
<td>Similarities</td>
<td>7.43 (2.11)</td>
<td>7.25 (2.38)</td>
<td>Impulsivity/Distractibility</td>
<td>72.00 (11.08)</td>
<td>70.79 (11.59)</td>
</tr>
<tr>
<td>Digit Span</td>
<td>7.08 (2.69)</td>
<td>6.54 (2.69)</td>
<td>Delinquency</td>
<td>69.86 (12.97)</td>
<td>66.58 (12.18)</td>
</tr>
<tr>
<td>Picture Concepts</td>
<td>9.06 (3.02)</td>
<td>7.76 (3.16)</td>
<td>Family Dysfunction</td>
<td>59.07 (14.70)</td>
<td>54.12 (11.29)</td>
</tr>
<tr>
<td>Coding</td>
<td>7.44 (3.18)</td>
<td>6.73 (2.97)</td>
<td>Reality Distortion</td>
<td>72.20 (16.24)</td>
<td>71.42 (14.03)</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>6.82 (2.23)</td>
<td>6.48 (2.54)</td>
<td>Somatic Concern</td>
<td>58.94 (12.98)</td>
<td>52.67 (11.01)</td>
</tr>
<tr>
<td>L-N Sequencing</td>
<td>8.27 (6.63)</td>
<td>6.90 (3.06)</td>
<td>Psychological Discomfort</td>
<td>72.24 (15.85)</td>
<td>69.06 (12.97)</td>
</tr>
<tr>
<td>Matrix Reasoning</td>
<td>8.39 (2.98)</td>
<td>7.33 (2.73)</td>
<td>Social Withdrawal</td>
<td>57.42 (15.12)</td>
<td>55.87 (12.01)</td>
</tr>
<tr>
<td>Comprehension</td>
<td>7.31 (2.21)</td>
<td>6.15 (2.33)</td>
<td>Social Skills Deficits</td>
<td>69.32 (12.88)</td>
<td>71.11 (12.35)</td>
</tr>
<tr>
<td>Symbol Search</td>
<td>9.54 (6.20)</td>
<td>8.79 (2.82)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>7.45 (1.87)</td>
<td>6.46 (2.75)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As can be seen in Table 4.8, the ADHD group performed higher than the FASD/ADHD group on each of the significant WISC-IV subtests. Regarding the PIC-2 adjustment scales, the FASD/ADHD group was rated higher on the Cognitive Impairment adjustment scale than the ADHD group. This pattern was reversed for the Somatic Concern and Family Dysfunction scales, with the ADHD group rated higher than the FASD/ADHD group.

**Classification and Regression Tree**

Two Classification and Regression Trees (CART) were used in the current study to assist in clinical decision making and differential diagnosis based on the subtests examined in this study. The two CARTs utilized the WISC-IV subtests and PIC-2
adjustment scales as in the above MANOVAs and DDAs. CART provides the ability to build diagnostic trees by exploring interactions of the subtests from the WISC-IV and the adjustment scales from the PIC-2. For example, the CART procedure identifies specific cut-off scores on WISC-IV and PIC-2 variables to be used to classify the groups. This level of specificity is unavailable through MANOVA and DDA. Furthermore, CART has been shown to be highly accurate in two-group classification, including a higher degree of accuracy than Discriminant Analysis, especially when group sizes are discrepant (Holden, Finch, & Kelley, 2011). It should be noted that CART is a recursive separation algorithm that is nonparametric in nature. Therefore, there are not specific assumptions that need to be met as in parametric analyses, such as MANOVA and DDA.

The CART utilizing the WISC-IV subtests as predictors is displayed in Figure 4.1 and a summary of the results are displayed in Table 4.9.
Yes=FASD/ADHD
No=ADHD
Table 4.9

<table>
<thead>
<tr>
<th>Terminal Node (n)</th>
<th>Classification</th>
<th>Characterization</th>
<th>Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (11)</td>
<td>FASD/ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=82%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&lt;3.5</td>
<td>ADHD=18%</td>
</tr>
<tr>
<td>2 (13)</td>
<td>ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=31%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;3.5</td>
<td>ADHD=69%</td>
</tr>
<tr>
<td>3 (5)</td>
<td>FASD/ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;3.5</td>
<td>ADHD=20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&lt;5.5</td>
<td></td>
</tr>
<tr>
<td>4 (6)</td>
<td>ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;3.5</td>
<td>ADHD=100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&lt;8.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coding&lt;4.5</td>
<td></td>
</tr>
<tr>
<td>5 (6)</td>
<td>FASD/ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;3.5</td>
<td>ADHD=33%</td>
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<tr>
<td></td>
<td></td>
<td>Comprehension&gt;5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&lt;8.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coding&gt;4.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coding&gt;7.5</td>
<td></td>
</tr>
<tr>
<td>6 (7)</td>
<td>FASD/ADHD</td>
<td>Information&lt;5.5</td>
<td>FASD/ADHD=86%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;3.5</td>
<td>ADHD=14%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comprehension&gt;5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&gt;8.5</td>
<td></td>
</tr>
<tr>
<td>7 (8)</td>
<td>FASD/ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=62.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=37.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&lt;10.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarities&lt;4.5</td>
<td></td>
</tr>
<tr>
<td>8 (18)</td>
<td>ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=94%</td>
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<td></td>
<td>Block Design&lt;10.5</td>
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<tr>
<td></td>
<td></td>
<td>Similarities&gt;4.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarities&lt;6.5</td>
<td></td>
</tr>
<tr>
<td>9 (51)</td>
<td>ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&lt;10.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarities&gt;4.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarities&gt;6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information&lt;9.5</td>
<td></td>
</tr>
<tr>
<td>10 (9)</td>
<td>ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&lt;10.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarities&gt;4.5</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>Similarities&gt;6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information&gt;9.5</td>
<td></td>
</tr>
<tr>
<td>11 (22)</td>
<td>FASD/ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=59%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&gt;10.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coding&lt;9.5</td>
<td></td>
</tr>
<tr>
<td>12 (10)</td>
<td>ADHD</td>
<td>Information&gt;5.5</td>
<td>FASD/ADHD=20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pic Concepts&lt;12.5</td>
<td>ADHD=80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Block Design&gt;10.5</td>
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</tr>
</tbody>
</table>
The first CART procedure using the WISC-IV subtests as predictors resulted in a hierarchical decision tree with 13 terminal nodes. The residual mean deviance, a measure of within terminal node variation, was 1.045 (176.7/169) and the misclassification rate was 0.24 (44/182). These results show that the decision tree was 76% accurate in predicting group membership. In regards to the residual mean deviance, larger values are considered worse. Although the value alone does not provide much information, it allows for comparisons of the relative performance of two different trees. As documented in Figure 1 and Table 4.9, the primary variable differentiating the FASD/ADHD and the ADHD group was the Information subtest. The column labeled “Characterization” in Table 4.9 outlines the specific flow of the decision tree created by the CART analysis. The “Group Membership” column describes the accuracy of the node in classification. For example Terminal Node 1 resulted from a pattern of performance characterized by Information scores below 5.5 and Comprehension scores below 3.5. This node was classified as FASD/ADHD with 82% accuracy.

The CART utilizing the PIC-2 adjustment scales as predictors is displayed in Figure 4.2 and a summary of the results are displayed in Table 4.10.
Yes=FASD/ADHD

No=ADHD
As seen in Figure 2 and Table 4.10, the resulting CART analysis revealed a hierarchical decision tree with 10 terminal nodes. The residual mean deviance was 0.89 (153.6/172) and the misclassification rate was 0.19 (35/182). These results show that the decision tree was 81% correct in predicting group membership. The primary variable differentiating the FASD/ADHD and the ADHD group was the Somatic Concern adjustment scale.
Chapter V

Discussion

This chapter is divided into four sections: (1) summary of the present study; (2) discussion and implication of the findings; (3) limitations and delimitations of the study; and (4) directions for future research.

Summary of the Present Study

The purpose of the present study was to investigate similarities and differences in cognitive and personality functioning for children diagnosed with Fetal Alcohol Spectrum Disorders with Comorbid ADHD (FASD/ADHD) and children with ADHD without comorbid FASD (henceforth referred to as children with ADHD) as measured by the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003) and the Personality Inventory for Children – Second Edition (PIC-2; Lachar & Gruber, 2001). Furthermore, the current study examined the strength and nature of the relationship between the WISC-IV and the PIC-2 to determine if unique information was being collected by these measures. The current study also investigated cognitive and personality variables that best differentiate the two groups. Similarly, the current study sought to establish diagnostic decision-making trees utilizing performance
on the WISC-IV and PIC-2 as predictors of group classification. The data for this study were collected from 182 participants, which were divided into two diagnostic groups: 67 participants (mean age=9.68) diagnosed by a multidisciplinary team with FASD/ADHD and 115 participants (mean age=10.05) diagnosed with ADHD. All participants were administered the WISC-IV and had parent/caregiver completed rating scales for the PIC-2 as part of a comprehensive neuropsychological evaluation. Data for the current study were archival in nature and collected after completion of the neuropsychological evaluation.

The results will now be discussed in terms of the 10 research questions outlined in Chapter I.

R₁ What is the relationship between the WISC-IV and the PIC-2 for the children with FASD/ADHD?

The results of the canonical correlation analysis for the FASD/ADHD group revealed that the WISC-IV and PIC-2 variables, when analyzed simultaneously, were not related to each other, suggesting that each set of variables contributed unique information to the current study. Pearson correlation coefficients (see Table 4.2) also revealed that most of the subtests from the WISC-IV and the adjustment scales from the PIC-2 were unrelated. There were, however, some statistically significant relationships between the Cognitive Impairment scale from the PIC-2 and several of the WISC-IV subtests including the Block Design, Similarities, Digit Span, Vocabulary, Matrix Reasoning, and Information subtests.
R_2 What is the relationship between the WISC-IV and the PIC-2 for the children with ADHD?

The canonical correlation analysis investigating the relationship between the set of WISC-IV variables and the set of PIC-2 variables also was not statistically significant for the ADHD group, suggesting that each instrument provided distinctive information to the current investigation. Review of the Pearson’s correlation coefficients (See Table 4.2) among the WISC-IV and PIC-2 scales revealed significant relationships between the Cognitive Impairment scale from the PIC-2 and the Similarities, Picture Concepts, Coding, and Information subtests from the WISC-IV. Significant relationships were also found between the Impulsivity and Distractibility adjustment scale and the Picture Concepts and Comprehension subtests. Furthermore, the Psychological Discomfort scale and the Block Design subtest, and the Social Withdrawal scale and the Letter-Number Sequencing subtest were significantly related.”

R_3 What is the WISC-IV profile of children with FASD/ADHD and children with ADHD?

Review of the cognitive profiles of each diagnostic group (see Table 4.8) revealed that the ADHD group scored higher on all of the WISC-IV subtests than the FASD/ADHD group. Examination of each of the subtests indicates that none of the group means met or exceeded the normative sample mean of 10. However, the ADHD group performed within one standard deviation of the mean for all subtests except for Vocabulary. The FASD/ADHD group had scores within one standard deviation of the mean in the following subtests: Block Design, Similarities, Picture Concepts, Matrix
Reasoning, and Symbol Search. The Digit Span, Coding, Vocabulary, Letter-Number Sequencing, Comprehension, and Information subtest all were lower than one standard deviation from the mean, suggesting more pronounced deficits.

R4 Are there significant cognitive differences between children with FASD/ADHD and children with ADHD as measured by the subtest scores on the WISC-IV?

The results of the MANOVA utilizing the WISC-IV subtests (see Table 4.5) were statistically significant, indicating that there are significant cognitive differences between the two groups as measured by the WISC-IV.

R5 What is the profile of adjustment scales on the PIC-2 for children with FASD/ADHD and for children with ADHD?

Review of the personality profiles of each diagnostic group (see Table 4.8) revealed that the FASD/ADHD group showed more pronounced deficits on the Cognitive Impairment and Social Skills Deficits adjustment scales. However, the ADHD group was reported to have more deficits on the remaining seven adjustment scales (Impulsivity/Distractibility, Delinquency, Family Dysfunction, Reality Distortion, Somatic Concern, Psychological Discomfort, and Social Withdrawal). The FASD/ADHD group exhibited more deficits than the normative sample by one or more standard deviations on all adjustment scales except for the Family Dysfunction, Somatic Concern, and Social Withdrawal adjustment scales, all of which fell within normal limits. The ADHD group followed the same pattern with the Family Dysfunction, Somatic Concern, and Social Withdrawal scores all falling within normal limits, and the remaining adjustment scales suggestive of increased impairment.
R₆ Are there significant personality differences between children with FASD/ADHD and ADHD as measured by the PIC-2 adjustment scales?

The results of the MANOVA using the PIC-2 adjustment scales (see Table 4.6) were statistically significant, indicating that there were significant differences between the two groups.

R₇ What cognitive variables best differentiate the FASD/ADHD and ADHD groups?

The results of the DDA using the WISC-IV variables revealed that the WISC-IV subtest contributing the most to differences between the groups was the Comprehension subtest, with the ADHD group scoring higher than the FASD/ADHD. The Picture Concepts, Information, Matrix Reasoning, and Letter-Number Sequencing subtests also contributed to group differences, with the ADHD group scoring higher on these subtests as well.

R₈ What personality variables best differentiate the FASD/ADHD and ADHD groups?

The results of the DDA using the PIC-2 adjustment scales revealed that the best differentiator was the Cognitive Impairment adjustment scale. Specifically, the FASD/ADHD group exhibited more impairment than the ADHD group. The Somatic Concern and Family Dysfunction adjustment scales were also shown to be good predictors of group differences, though for these variables the ADHD group was shown to have more pronounced deficits than the FASD/ADHD group.
R9 What are the specific WISC-IV subtests that most likely classify a diagnosis of FASD/ADHD or ADHD?

The results of the CART procedure using the WISC-IV variables as predictors revealed that the primary predictor of group membership was the Information subtest. Specifically, participants with scores above 5.5 belonged to the ADHD group with 70% accuracy and participants with scores below 5.5 belonged to the FASD/ADHD with 56% accuracy. The accuracy of classification rose when additional predictor variables were added. Specific subtests found to differentiate the groups best in the CART procedure included the Comprehension, Block Design, Coding, Picture Concepts, and Similarities subtests.

R10 What are the specific PIC-2 adjustment scales that most likely classify a diagnosis of FASD/ADHD or ADHD?

The results of the CART procedure using the PIC-2 variables as predictors revealed that the primary predictor of group membership was the Somatic Concern adjustment scale. Specifically, 51% of participants with scores below 54 were from the FASD/ADHD group and 76% of participants with scores above 54 belonged to the ADHD group. The accuracy of classification rose when additional PIC-2 adjustment scale scores were used as predictors. Specific adjustment scales that best differentiated the groups in the PIC-2 CART included the Cognitive Impairment, Reality Distortion, Social Skills Deficits, Family Dysfunction, and Impulsivity/Distractibility adjustment scales.
Discussion and Implications

Research investigating differences between children diagnosed with FASD/ADHD and children diagnosed with ADHD has been sparse. Although there has been a proliferation of research investigating each group individually, investigations into similarities and differences between the groups has not been conducted at the same pace. This discrepancy is surprising given the high level of comorbidity between the two groups. Specifically, research has demonstrated the probability of having a comorbid ADHD diagnosis in children with FASD ranges from 41 to 95% (Bhatara et al., 2006; Fryer et al., 2007; Herman et al., 2008; Walthall et al., 2008). This study investigated the relationship between the PIC-2 and the WISC-IV in children with FASD/ADHD and children with ADHD. The current investigation also explored cognitive and personality functioning in children with FASD/ADHD and children with ADHD and compared functioning between the two groups to determine if there were significant differences. Furthermore, the current study allows for further elucidation of the cognitive and personality profiles of both groups, which is lacking in the extant literature, especially for individuals with FASD (Kodituwakku et al., 2007; Kodituwakku 2009; Mattson et al., 2010; Rasmussen et al., 2006). The need for clarified cognitive and personality profiles for individuals with FASD is essential for accurate diagnosis and for developing interventions that accurately address the needs of these individuals.

WISC-IV and PIC-2 relationship.

The examination of the relationship between the WISC-IV and the PIC-2 for both groups revealed a lack of significance when each set of variables was compared simultaneously. These results are consistent with previous research documenting that
cognitive functioning is not related to elevations on measures of psychopathology (Correl, 1985; Gaines & Morris, 1978; Gervais, Ben-Porath, & Wygant, 2009). These results reveal that for the FASD and ADHD groups, the WISC-IV and PIC-2 provide unique and valuable information to a clinical evaluation. This is an important consideration given that measures of intelligence are more commonly used in school psychology evaluations than thorough measures of personality (such as the PIC-2). Therefore, school psychologists and other professionals should be careful in extrapolating personality functioning from intelligence for these children.

Although the two sets of variables were unrelated for each of the two groups in the current study, there were significant relationships between the target variables individually. For the FASD/ADHD group, the Cognitive Impairment adjustment scale from the PIC-2 was found to be significantly negatively correlated with several subtests from the WISC-IV. Elevations on the Cognitive Impairment adjustment scale are indicative of cognitive dysfunction one or more standard deviations below the mean, with corresponding deficits in academic achievement and adaptive functioning (Lachar & Gruber, 2001). This significant relationship between subjective reports and objective measures of cognitive functioning suggests that the Cognitive Impairment scale may be a good screening tool for cognitive impairment in the FASD population. The Cognitive Impairment scale was also inversely related to several WISC-IV subscales for the ADHD group, demonstrating the potential utility for the Cognitive Impairment as a screening tool for children with ADHD. The use of the PIC-2 as a screening tool for cognitive impairment could increase early detection of cognitive deficits, thus increasing the likelihood of providing early intervention services to children in need. Given the present
results, school psychologists are encouraged to utilize the PIC-2 not only as a multiple domain assessment of personality functioning, but also as a screening tool for cognitive impairment in children with FASD/ADHD and children with ADHD.

**Cognitive profile of children with FASD/ADHD and children with ADHD.**

Examination of the cognitive profiles of the FASD/ADHD group and the ADHD group revealed performance across subtests was largely below that of the normal population mean, which is consistent with previous research documenting global cognitive deficits for both groups (Frazier et al., 2004; Mayes & Calhoun, 2004; Mukherjee, Hollins, & Turk, 2006; Riley & McGee, 2005; Vaurio, Crocker, & Mattson, 2011). Specifically, the means for both groups failed to meet a scaled score of 10 on all of the WISC-IV subtests. However, when comparing cognitive functioning between the groups, the FASD/ADHD exhibited more cognitive deficits than the ADHD group,

Verbal abilities have been documented as an area of relative and normative weakness for individuals with FASD (Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). The current study confirmed these previous findings, with the mean performance on verbal tasks typically falling approximately one standard deviation below the mean. Although previous research has indicated that verbal abilities are an ipsative strength for individuals with ADHD, global performance on verbal tasks is typically lower than healthy controls (Andreou et al., 2005; Ek et al., 2007; Jakobson & Kikas, 2007). Results from the current investigation confirm the previous findings of impairment on verbal tasks relative to the normative sample. These results continue to elucidate the pattern of verbal functioning of both children with FASD and children with ADHD. Deficits in crystallized knowledge appear to be present for both groups, though
more pronounced for children with prenatal alcohol exposure. These findings have ramifications for instruction in the school setting as the primary mode of instruction delivery is through the verbal modality. Therefore, it is important for school psychologists and other school professionals to be aware of this pattern of performance and make appropriate accommodations for children with FASD and ADHD, such as providing visual-spatial representations of classroom instruction. Furthermore, children with FASD/ADHD and ADHD would benefit from having verbal instructions presented to them in written format to allow for reference back to material that may have been missed or forgotten.

Perceptual reasoning tasks have been proposed as an area of ipsative strength for individuals with FASD, though this has been a point of contention in studies attempting to outline a specific FASD cognitive profile (Kerns et al., 1997; Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). The results of the current study reveal that group means on the perceptual reasoning subtests for the FASD/ADHD group were generally higher than the verbal subtests. These results lend credence to previous research suggesting that a discrepancy between verbal and perceptual reasoning may be a part of the FASD cognitive profile. Perceptual reasoning deficits in individuals with ADHD has received limited support in the research, though a meta-analysis revealed slight, but statistically significant deficits in perceptual reasoning ability when compared to typically developing control groups (Frazier et al., 2004). The results of the current study revealed that ADHD group means on perceptual reasoning tasks fell within one standard deviation of the normative sample mean, indicating that marked perceptual reasoning deficits were not present. Given that ipsative strengths in visual-spatial
reasoning are characteristic of both groups, intervention development should focus on utilizing this strength when developing interventions and making classroom accommodations. Specifically, maximizing instructions presented in visual and spatial modalities will likely be beneficial to both children with FASD and ADHD. Additionally, children with ipsative strengths in visual-spatial ability would benefit from assignment modifications to allow for demonstration of knowledge to be accomplished through visual-spatial modalities, including pictures, graphs, charts, flowcharts, and other pictorial representations.

Deficits in working memory have been documented consistently both in individuals with FASD and ADHD. In fact, working memory deficits have been proposed as core features of the cognitive profile for individuals with FASD and individuals with ADHD (Barkley, 1997; Kodituwakku, 2009). The current study involved two measures of auditory working memory including a digit span task, which has been shown to be especially sensitive to prenatal alcohol exposure (Burden, Jacobson, Sokol, & Jacobson, 2006; Streissguth et al., 1999, Streissguth et al., 1990). Consistent with previous research, the results of the current investigation revealed deficits in auditory working memory to be a prominent feature of the group with FASD/ADHD. Working memory deficits were also present for the ADHD group, though these deficits were not as pronounced or as consistent as those seen in the FASD/ADHD group. Specifically, the ADHD group scored higher on both working memory tasks relative to the FASD/ADHD group. Additionally, the ADHD group mean for Letter-Number Sequencing fell within the Average range; however, there was a considerable amount of variability among individuals diagnosed with ADHD on this task. These results
document that working memory deficits are common to both children with FASD/ADHD and children with ADHD. This is unsurprising given that previous research has consistently documented this pattern of results. However, the important finding in the current study is that working memory deficits are more pronounced and more consistent for children with FASD/ADHD. Although there is a paucity of research comparing executive functions in FASD and ADHD, prior research has shown greater levels of impairment in verbal fluency, cognitive set shifting, and sequencing for children with FASD (Vaurio, Mattson, & Riley, 2008). Furthermore, deficits in attention have been shown to be unique for each group, with children with FASD exhibiting greater deficits in shifting attention, while children with ADHD display greater deficits in focused and sustained attention (Peadon & Elliott, 2010). The current findings support the notion that deficits in executive functioning, including working memory may be more substantial in children with FASD/ADHD. Therefore school psychologists should be aware of the more substantial working memory deficits present when working with children with FASD/ADHD in the school setting. Additionally, education of other school personnel as to the nature of the working memory deficits for these children should be prioritized to develop uniform accommodations. Suggestions for accommodations for these working memory deficits are discussed below.

Processing speed deficits have been identified as key elements of both the ADHD and the FASD cognitive profiles (Calhoun & Mayes, 2005; Mayes & Calhoun, 2007; Kodituwakku, 2007; Kodituwakku, 2009). Further research investigating performance on the Wechsler scales for Children identified the Coding subtest as a specific area of weakness for individuals with ADHD (Mayes & Calhoun, 2004; Mayes & Calhoun,
The results of the current study are consistent with previous research. Specifically, the Coding subtest was an area of weakness for the FASD/ADHD and the ADHD groups, though the FASD/ADHD exhibited more pronounced deficits. However, performance on Symbol Search, the second measure of processing speed used in the current study, was found to be higher for both groups than Coding. Although both the Coding and Symbol Search subtests are measures of processing speed, the Coding subtest requires more complex graphomotor functions for accurate completion of the task. Therefore, the results indicate that deficits in Coding may be a key component of the cognitive profiles of both groups, suggesting that graphomotor deficits are likely prevalent in FASD and ADHD. Deficits in graphomotor processing have implications for possible classroom difficulties as graphomotor deficits have been linked closely to academic achievement, especially in the ADHD population (Mayes & Calhoun, 2007). Furthermore, Coding has been shown to be one of the most sensitive measures of neurological insult, even when other measures of cognitive functioning are largely intact (Lezak, Howieson, & Loring, 2004). Therefore, the current findings are supportive of a neurobiological basis for ADHD and the deficits seen in FASD, as Coding deficits were a prominent feature of the FASD/ADHD and the ADHD cognitive profiles.

In sum, analysis of the results of the current study reveals that the cognitive profile for the FASD/ADHD group is marked by global deficits in working memory, as well as specific deficits on the Coding subtest. The FASD/ADHD group also appeared to perform better on visual-spatial processing tasks than on tasks measuring verbal processing. Furthermore, the FASD/ADHD group exhibited mean scores falling below the mean of the normative sample on all WISC-IV subtests, as well as below the
measured functioning of the ADHD group. These findings are consistent with previous research documenting that cognitive impairment is typically worse in individuals with FASD versus those with ADHD. The current findings, which document specific cognitive deficits in the absence of mental retardation, highlight the need for increased awareness of the cognitive sequelae of prenatal alcohol exposure. This has implications for treatment and interventions in that children with the cognitive deficits inherent in FASD may not fit into current psychiatric nosology or special education classifications, thus reducing the likelihood of receiving treatment. The current study provides an additional piece of information toward the goal of elucidating a specific cognitive profile among individuals with FASD, which in turn will result in more accurate diagnosis and intervention development. Without identification of a clear cognitive profile it is likely that many children with FASD will continue to be under diagnosed or misdiagnosed. Furthermore, targeted interventions for the FASD population will continue to lag behind disorders with greater awareness, though lower prevalence, without identification of specific areas in need of intervention for the FASD population.

Overall, the global cognitive profile of ADHD group in the current study was marked by general performance below that of the normative sample. Furthermore, the lowest score obtained by the ADHD group was on the Vocabulary subtest and the highest was on the Symbol Search subtest. Overall, this pattern of performance is inconsistent with previous ADHD research documenting areas of relative weakness in processing speed and relative strength in verbal ability. However, the ADHD group exhibited a relative strength in visual-spatial processing, which is consistent with prior research. Although the current study was not fully consistent with previously identified cognitive
profiles for individuals with ADHD, the dissimilar results may be explained by the fact that the participants in the current study had been referred for a clinical neuropsychology evaluation. Therefore, it is certainly possible that they were exhibiting more significant deficits, perhaps in multiple areas of functioning, as someone felt it necessary for them to receive a comprehensive neuropsychological evaluation. Specifically, arguments have been made by prominent researchers in the ADHD field indicating that neuropsychological evaluations are unnecessary for the diagnosis of ADHD, suggesting that many children with ADHD are unlikely to undergo a neuropsychological evaluation (Barkley & Edwards, 2006; Gordon, Barkley, & Lovett, 2006). Further research is needed to determine if these findings are representative of the clinical ADHD population.

**Personality profile of children with FASD/ADHD and children with ADHD.**

Examination of the personality profiles of FASD/ADHD group and ADHD group revealed several areas of potential pathology, which is consistent with previous research documenting high levels of psychiatric comorbidity among children with FASD and children with ADHD (Famy et al., 1998; Wilens et al., 2002; Young & Gudjonsson, 2006). The general personality profiles of both groups were similar in the current investigation, though the magnitude of impairment varied across personality domains. Specifically, both groups were reported by caregivers to be functioning within normal limits in the Family Dysfunction, Somatic Concern, and Social Withdrawal domains and were reported to have pathology exceeding that of their peers in the Cognitive Impairment, Impulsivity and Distractibility, Delinquency, Reality Distortion, Psychological Discomfort, and Social Skills Deficits domains. It should be noted that elevations on the PIC-2 adjustment scales are indicative of greater levels of pathology.
Elevations on the Cognitive Impairment scale were reported for both groups, which is unsurprising given previous reports of cognitive deficits being commonplace for both FASD and ADHD. The caregiver-reported elevations on the Impulsivity and Distractibility adjustment scale were also expected given that impulsivity and distractibility are core components of ADHD. Both the FASD/ADHD group and the ADHD group were also reported to have elevations on the Delinquency scale, suggesting the groups are at risk for engaging in antisocial behavior and at risk for involvement with the criminal justice system, which is consistent with previous research (Sibley et al., 2011; Streissguth et al., 2004; Teplin et al., 2002). These findings suggest that it may be advantageous for school and mental health professionals to engage in primary prevention of delinquent behaviors in children diagnosed with FASD/ADHD or with ADHD; it should be noted that some of the aforementioned cognitive and personality deficits may interfere with some manualized treatments for at-risk youth. Prioritizing primary prevention programming is important as delinquency prevention programs have been shown to efficacious for at-risk youth (Hill, Roberts, Grogger, Guryan, & Sixkiller, 2011; Oesterle, Hawkins, Fagan, Abbot, & Catalano, 2010).

Both groups also exhibited elevations on the Reality Distortion scale suggesting elevated prevalence of developmental anomalies, including increased need for peer assistance and poor adaptability. Deficits in these areas have been well documented in the extant literature for both individuals with FASD and individuals with ADHD (Barkley, 2006; Kalberg et al., 2006; Niccols, 2007). Caregiver-reported impairment was also present in the domain of social skills, which is also consistent with previous research (Hodgens et al., 2000; Hoza, 2007; Jirikowic et al., 2008). The elevations present on the
Reality Distortion scale suggest that children with FASD/ADHD and children with ADHD are likely in need of strong social support to help overcome developmental deviations; however, a lack of social skills is likely to impede the development of these critical social support networks. Therefore, school psychologists and mental health professionals should strongly consider the potential benefits of social skills training for children with FASD/ADHD and ADHD. Social skills training has been shown to ameliorate social skills deficits and increase peer acceptance, which in turn have numerous benefits in the school settings, including increased academic achievement and reduced behavior problems (Boo & Prins, 2007; Henricsson & Rydell, 2006).

The Psychological Discomfort scale, a measure of negative affect, was also elevated for both groups, revealing high levels of psychiatric concerns from the caregivers of the participants in the current study. Elevations on the Psychological Discomfort scale are indicative of internalizing problems, including low self-esteem, emotional lability, and anxiety (Lachar & Gruber, 2001). These results were also expected given the well-documented prevalence of psychiatric comorbidity in FASD and ADHD (Famy et al., 1998; Fryer et al., 2007; O'Connor, et al., 2002; Wilens et al., 2002). The high comorbidity of psychiatric problems in the FASD and ADHD populations indicates that children with these diagnoses should be closely monitored in the school setting. Given the utility of the PIC-2 in the current study, school professionals are encouraged to utilize multiple domain tools, such as the PIC-2 for assessing a broad range of social, emotional, and behavioral functioning in school setting.

Overall, the cognitive and personality profiles of the participants with FASD/ADHD and ADHD are consistent with previous research. Of note, however, was
the lack of reported family dysfunction for both groups. This finding was surprising given that previous research has documented high levels of familial stress for families of children with FASD and ADHD (Barkley, 2006; Kaplan, et al., 1998; Kelly et al., 2000). It is unclear if this finding is an artifact of the current sample or if previous findings of family dysfunction are not representative of these samples of children with FASD and ADHD. Regardless, continuing research is needed to determine the nature of family relationships in the families of children with FASD and ADHD and how they affect cognitive and emotional functioning. Both groups in the current investigation displayed similar patterns of cognitive and personality functioning, though the cognitive and personality profiles of both groups were not identical. These results emphasize the need for methods of differentiating the groups, especially when prenatal alcohol exposure is unknown. Given that the profiles of both groups are similar yet unique, specific clinical guidelines are needed to assist in differential diagnosis.

Differences in cognitive and personality functioning among children with FASD/ADHD and children with ADHD.

The results of this study documented significant differences between children with FASD/ADHD and children with ADHD regarding cognitive and personality functioning. These findings have clinical significance as they demonstrate there are measurable differences between the groups, thus indicating that each group has unique underlying deficits. In considering these differences, it becomes evident that unique treatment and interventions are likely needed for each group. Therefore, in order to begin to develop unique interventions it is imperative that specific areas in which the two groups differ are identified. This is especially important for individuals with FASD, as
there are myriad evidence-based treatments for individuals with ADHD, yet a paucity of
evidence-based treatments for individuals with FASD (Caley, Shipkey, Winkleman,
Dunlap, & Rivera, 2006; Chronis, Jones, & Raggi, 2006; Peadon et al., 2009).

**Cognitive differences.**

The current study has shown there are significant differences in cognitive
functioning between children with FASD/ADHD and children with ADHD. Specifically,
children with FASD/ADHD were shown to have significantly more difficulty than
children with ADHD on verbally-based tasks of social judgment, verbal
conceptualization, and verbal comprehension tasks. This has important ramifications for
children with FASD in the school setting, as the primary mode of communication in the
classroom is through verbal means. These deficits suggest that future interventions for
individuals with FASD should focus on ameliorating verbal processing deficits. Specific
strategies that can be used include using concrete language, utilizing other modes of
classroom instructions, including visual, tactile, and kinesthetic approaches, encouraging
the use of peer modeling to assist in learning new skills, and allowing adequate time for
the children with FASD to process verbal information (Bernstein-Clarren, 2004).

Additionally, awareness should be given to the fact that children with FASD may appear
to have appropriate verbal fluency, but lack the ability to adequately communicate verbal
concepts. Children with this pattern of communication deficits will be able to
superficially discuss concepts in a concrete manner, but will likely lack the ability to
convey understanding of abstract concepts. Furthermore, these children may be unable to
successfully express their needs to adults.
The current study revealed that visual-spatial abstract reasoning, visual conceptualization, and fluid reasoning were additional areas where the FASD/ADHD group performed significantly worse than the ADHD group. These differences in visual-spatial abstraction and fluid reasoning between the groups indicate that this is an area of specific need for individuals with FASD/ADHD, and likely an area overlooked by extant ADHD interventions when used for children with FASD. Specific approaches to managing deficits in fluid reasoning and visual-spatial abstraction include utilizing activities to activate previously learned material, using manipulatives to make abstract visual concepts concrete, using multiple concrete examples of newly-presented material, and providing external visual structure for the child through the use of highlighting and material modification.

Auditory working memory was another cognitive domain shown to differentiate the FASD/ADHD group and the ADHD group, with the FASD/ADHD group having more difficulty. Although working memory deficits are characteristic of both FASD and ADHD, the current results reveal that these deficits are more pronounced in individuals with comorbid FASD/ADHD. These results indicate that intervention and accommodations for individuals with FASD/ADHD should focus heavily on auditory working memory deficits. Specific strategies that may be utilized to accommodate for auditory working memory deficits include providing instructions one piece at a time and utilizing written instructions and lists the child can refer to after verbal instructions have passed. Furthermore, a useful intervention may be to teach children to create their own lists and notes to refer to after verbal instructions. Rehearsal training has also been
documented to be an effective intervention for working memory deficits in children with FASD (Loomes, Rasmussen, Pei, Manjia, & Andrew, 2008).

**Personality differences.**

Comparison of caregiver-reported personality functioning revealed that reported cognitive impairment was the most important contributor to group differences with children with FASD/ADHD reported as exhibiting more impairment than the ADHD group. These results reveal that children with FASD are more likely to have perceived deficits in intellectual functioning, poor school adjustment and enjoyment, and delays in developmental milestone acquisition. The findings are consistent with the objective measures of cognitive functioning used in the current study that documented cognitive impairment is more pronounced for individuals with FASD/ADHD. The fact that caregivers of children with FASD/ADHD are able to accurately report cognitive impairment on a personality measure indicates that caregiver rating scales may be adequate screening tools for cognitive deficits secondary to prenatal alcohol exposure. The use of quick and efficient screening tools has the potential to increase recognition of cognitive impairments at an earlier age, thus making earlier identification and intervention more likely. Tools that allow for earlier identification of FASD are much needed as individuals with FASD typically are not identified until age 9.5, which is when many of the benefits of early intervention have passed (Olson, Jirikowic, Kartin, & Astley, 2007). Furthermore, the importance of early identification and treatment is reinforced by animal research demonstrating that enriched postnatal environments can attenuate deficits that result from prenatal alcohol exposure (Idrus & Thomas, 2011; Thomas, Sather, & Whinery, 2008).
Somatic Concern and Family Dysfunction, measures of health complaints without clear physical cause and of family conflict and disharmony respectively, were also areas of importance regarding group differences, with the ADHD group reported to have levels exceeding those of the FASD/ADHD group, indicating greater levels of reported impairment. However, it should be noted that although there were significant differences between the groups on these two scales, the means for both groups fell within normal limits. These results are consistent with previous research, which has largely lacked support for increased somatic complaints for individuals with FASD or ADHD (Egger et al., 1999). Interestingly, it appears that these scales have potential for differential diagnosis, which will be discussed in more detail below.

Classification utilizing WISC-IV.

One of the aims of the current study was to investigate the capability of the WISC-IV and the PIC-2 to differentiate between children with FASD/ADHD and children with ADHD, and to determine how performance on specific subtests and adjustment scales best classifies the groups. Given the above results, which document differences in cognitive and personality functioning between children FASD/ADHD and ADHD, it is clear that unique interventions are likely needed for each group. However, given the high level of similarity between the cognitive and personality profiles of the groups, clinicians may have difficulty in differentiating the groups, especially when prenatal alcohol exposure is unknown or unquantifiable. Therefore, an effective tool is needed to aid in differential diagnosis. A CART analysis was used to create a decision tree using the WISC-IV and the PIC-2 separately to assist in clinical decision making. The results of WISC-IV CART revealed that the primary subtest for differentiating the
groups was the Information subtest, with lower scores on the subtest associated with FASD/ADHD diagnosis and higher scores more closely associated with ADHD diagnosis. The Information subtest is a measure of crystallized knowledge, suggesting that prenatal alcohol exposure may interfere with the building of a general fund of knowledge. This finding is consistent with neuroimaging documenting abnormalities in several brain areas of individuals with FASD that are needed for intact language and memory, including the corpus callosum, cerebellum, basal ganglia, hippocampus, and thalamus (Archibald et al., 2001; Astley et al., 2009; Fryer et al., 2009; Norman et al., 2009; Riikonen et al., 1999; Sowell et al., 2010; Wilford et al., 2010).

Although the Information subtest was the primary WISC-IV subtest that differentiated the groups, the addition of other WISC-IV subtest performance in the decision tree resulted in more accurate classification (See Figure 4.1). Examination of terminal nodes 1 and 2, which both were characterized by Information scores below 5.5, reveals that the addition of performance on the Comprehension subtest greatly increased the accuracy of classification of FASD/ADHD or ADHD. Specifically, impaired Information performance and markedly impaired Comprehension scores were characteristic of the FASD/ADHD group (Terminal Node 1), while more moderate impairment on the Comprehension subtest was indicative of ADHD classification. It is not surprising that profound impairment on the Comprehension subtest is diagnostic of FASD/ADHD given that it is a measure of social judgment and knowledge, which has been documented by the current study and previous research as an area of significant difficulty for individuals with FASD (Brown et al., 2010; Crocker et al., 2009; Jirikowic et al., 2008). Therefore, it appears that deficits in verbal ability are highly characteristic
of the FASD/ADHD group, suggesting that performance on measures of verbal ability may be a useful tool for differentiating FASD/ADHD from ADHD. This finding is promising for the future of differential diagnosis of FASD as a specific pattern of performance on the verbal subtests on the WISC-IV may be able to be used for classification. Given that the WISC-IV is one of the most commonly used measures of cognitive functioning in the field of psychology, it is certainly possible that most clinicians may already have the tools needed to aid in differential diagnosis (Strauss, Sherman, & Spreen, 2006).

Terminal node 13 on the WISC-IV decision tree, which consisted of an Information score above 5.5 and a Picture Concepts score above 12.5, placed participants in the ADHD group at a rate of 94%. This pattern of performance was highly predictive of ADHD group placement, indicating that the children with ADHD are more likely to have better developed verbal abilities, and visual abstraction and categorization abilities than children with FASD/ADHD. This pattern is consistent with the results of the current study documenting that children with FASD/ADHD generally perform lower on measures of cognitive functioning than children with ADHD.

The WISC-IV CART also contained more complex combinations of WISC-IV variables to classify participants. Terminal node 7 from the WISC-IV CART consisted of Information scores above 5.5, Picture Concepts below 12.5, Block Design below 10.5, and Similarities below 4.5. This pattern of performance resulted in classification of FASD/ADHD at a rate of 63%. This node reinforces a pattern seen in the decision tree that significant impairment on verbal subtests from the WISC-IV is largely indicative of FASD/ADHD group placement, which is consistent with previous research documenting
significant deficits in verbal abilities for individuals with FASD (Astley et al., 2009; Carr, et al., 2010; Kodituwakku, 2009; Mattson & Riley, 1998; Streissguth et al., 1999).

The utility of the verbal subtests from the WISC-IV in the differential diagnosis of FASD/ADHD and ADHD is strengthened through review of terminal nodes 8, 9, and 10 marked by an initial pattern of performance of Information scores above 5.5, Picture Concepts below 12.5, Block Design below 10.5, and Similarities above 4.5. Specifically, the nodes are characterized by the previous pattern of performance with terminal node 8 having a Similarities score below 6.5, terminal node 9 with Similarities above 6.5 and Information below 9.5, and terminal node 10 with Similarities above 6.5 and Information above 9.5. All three of these nodes were classified as ADHD, documenting that higher scores on the verbal subtests, specifically the Information and Similarities subtests, is largely diagnostic of the ADHD group. This is especially true for terminal node 10, which resulted in 100% classification in the ADHD group.

Terminal nodes 11 and 12 contained participants with Information scores above 5.5, Picture Concepts below 12.5, Block Design above 10.5, and Coding either above or below 9.5. For these nodes, those scoring below 9.5 on Coding (terminal node 11) were classified as FASD/ADHD at a rate of 59% and those scoring above 9.5 on Coding (terminal node 12) were classified as ADHD at a rate of 80%. These results indicate that performance on the Coding subtest, a measure of processing speed, visual attention, and perceptual motor skills, differentiates the FASD/ADHD group and the ADHD group when the above pattern of scores is obtained. Specifically, lower performance on Coding is indicative of an FASD/ADHD diagnosis and higher performance is indicative of ADHD diagnosis. Although previous research has documented processing speed deficits
for both individuals with FASD and individuals with ADHD, the current results indicate that poorer performance on the Coding subtest is more closely associated with individuals diagnosed with FASD/ADHD, suggesting a greater level of neurological impairment may be present (see Lezak, Howieson, & Loring, 2004).

The remaining terminal nodes in the WISC-IV CART were characterized by Information scores below 5.5 and Comprehension above 5.5. Terminal node 3 contained this pattern of performance and was also typified by Block Design scores below 8.5 and Coding scores below 4.5. This node was classified as FASD/ADHD with 80% accuracy. Terminal node 3 is consistent with the previously described nodes documenting that deficits in crystallized knowledge and processing speed are characteristic of the FASD/ADHD group. Terminal node 4 had Block Design scores below 8.5 and Coding scores between 4.5 and 7.5 and was classified as ADHD with 100% accuracy suggesting that this pattern of performance, characterized by deficits in fund of knowledge, below average visual-gestalt formation, and Coding scores of 5 or 6, is largely indicative of an ADHD diagnosis versus an FASD/ADHD diagnosis. Terminal node 5 had Block Design scores below 8.5 and Coding scores above 7.5. This node was classified as FASD/ADHD with 67% accuracy. This node details that although processing speed deficits are common in the FASD/ADHD group some participants exhibited intact processing speed. However, these participants still displayed deficits in crystallized knowledge and below average visual-spatial processing. Therefore, it appears that processing speed deficits are a core piece of the FASD cognitive profile, though performance in this area may be more variable than other parts of the profile, such as impaired crystallized knowledge.
The final terminal node, terminal node 6, of the WISC-IV CART was characterized by Information scores below 5.5, Comprehension scores above 5.5, and Block Design scores above 8.5. This node was classified as FASD/ADHD with 86% accuracy. This node indicates that a cognitive profile with deficits in crystallized knowledge and visual-spatial processing within normal limits is highly suggestive of an FASD/ADHD, which is supportive of previous research hypothesizing a relative weakness in verbal ability when compared to visual-spatial processing for individuals with FASD (Kaemingk & Paquette, 1999; Kodituwakku, 2009; Mattson & Riley, 1998). Therefore, the current results continue to support the notion that ipsative strengths in visual-spatial processing and ipsative weaknesses in verbal processing are a core feature of the FASD cognitive profile and may be useful in differential diagnosis of FASD/ADHD versus ADHD.

**Classification utilizing PIC-2.**

The results of the PIC-2 CART revealed the primary adjustment scale for differentiating the groups was the Somatic Concerns scale, with a score of 54 as the differentiation point between the groups (see Figure 4.2). Scores above 54 were associated with an ADHD diagnosis and scores below 54 were largely split between participants diagnosed with FASD/ADHD and those with ADHD. Therefore, it appears that scores on the Somatic Concern adjustment scale have some clinical utility in differential diagnosis when scores are above 54, though scores below 54 do little to separate the groups without the addition of other PIC-2 subscales. The Somatic Concern scale is a measure of physical health concerns and of physical feelings associated with anxiety. Elevations on this scale are indicative of a tendency to convert psychological
stressors into physical symptoms. The results of the PIC-2 CART indicate that higher levels of somatic concerns are more closely associated with an ADHD diagnosis. Perhaps, children with ADHD more acutely experience somatic complaints or are just more likely to complain of them to their caregivers.

Although the Somatic Concern adjustment scale was the primary PIC-2 adjustment scale that differentiated the groups, the addition of other PIC-2 scales resulted in more accurate classification. The addition of the Cognitive Impairment and Reality Distortion scales resulted in two terminal nodes that were highly accurate in classifying the ADHD group. The specific constellation of scores included scores below 54 on Somatic Concern, below 63.5 on Cognitive Impairment, and either above or below 54.5 on Reality Distortion. Terminal node 1 contained scores below 54.5 on Reality Distortion and was a pure node with 100% classification as ADHD. Terminal node 2 contained Reality Distortion scores above 54.5 and was classified as ADHD with 70% accuracy. The Reality Distortion scale is a measure of the degree of disability present, with elevations suggestive of emotional dysregulation and adaptive skills deficits. Therefore, the results suggest that children with lower caregiver reports of somatic complaints, cognitive impairment, emotional lability, and adaptive skills are much more likely to be diagnosed with ADHD versus FASD/ADHD. Furthermore, higher levels of reported emotional dysregulation and adaptive skills deficits, in the absence of cognitive deficits was most suggestive of an ADHD diagnosis. These results document the importance of the Cognitive Impairment score in classifying the groups, as these ADHD nodes were both characterized by relatively low caregiver report of impairment, regardless of the level of emotional dysregulation and adaptive skills deficits present.
Four additional terminal nodes were present on the side of the decision tree characterized by scores below 54 on the Somatic Concerns adjustment scale. Terminal node 3 resulted from scores above 63.5 on Cognitive Impairment, below 82 on Social Skills Deficits, and below 70.5 on Cognitive Impairment. This node was classified as FASD/ADHD with 86% accuracy, suggesting that children with few somatic complaints and moderate levels of reported cognitive impairment, in the absence of profound social skills deficits, are more likely to be classified as FASD/ADHD. This same pattern was observed in a terminal node 5 characterized by Somatic Concerns scores below 54, Cognitive Impairment above 63.5, Social Skills Deficits below 82, and Cognitive Impairment above 73.5, which predicted FASD/ADHD classification with 65% accuracy. Although it appears that caregiver report of few somatic complaints and elevated levels of cognitive impairment is largely diagnostic of FASD/ADHD, terminal node 4 was an anomalous terminal node and was characterized by scores below 54 on Somatic Concerns, below 82 on Social Skills Deficits, and between 70.5 and 73.5 on Cognitive Impairment, which was classified as an ADHD node with 89% accuracy. Therefore, it seems there are a small proportion of ADHD participants in the current study for whom significant levels of reported cognitive impairment are present.

Terminal node 6 was the final terminal node on the side of the decision tree with Somatic Concern scores below 54. It was characterized by Cognitive Impairment scores above 63.5 and Social Skills Deficits above 82. Terminal node 6 resulted in 100% classification as FASD/ADHD. These results indicate that caregiver report of low somatic complaints, increased cognitive impairment, and profound social skills deficits is exclusively representative of an FASD/ADHD diagnosis in the current study. It should
be noted that the current sample was devoid of children with diagnoses of Mental Retardation, indicating that these social skills deficits are not accounted for by the global deficits that might be seen in those with Mental Retardation. Rather, these results seem to suggest that social skills deficits are a unique aspect of the behavioral phenotype of FASD. These results are consistent with previous research documenting the presence of impaired social functioning in individuals with FASD (Crocker et al., 2009; Franklin et al., 2007; Kelly et al., 2000; McGee, 2008). Although social deficits have long been known to be present in individuals with FASD, the current study reveals that an objective measure of social, emotional, and behavioral functioning can be a powerful clinical tool in the differential diagnosis of FASD/ADHD and ADHD.

As mentioned previously, scores above 54 on the Somatic Concern adjustment scale were suggestive of ADHD diagnosis with 76% accuracy. However, more complex combinations of PIC-2 scores further differentiated the two groups. In fact, terminal nodes 7 through 10 were present on the decision tree beginning with scores above 54 on the Somatic Concern adjustment scale. Terminal node 7 was created from Family Dysfunction scores below 53 and Cognitive Impairment scores below 80.5. This node was classified as ADHD with 72% accuracy, indicating that higher levels of somatic complaints appear to be predictive of ADHD even when reported cognitive deficits and problematic family interactions are lower. Terminal node 8 consisted of Somatic Concern scores above 54, Family Dysfunction below 53, and Cognitive Impairment above 80.5. This node was classified as FASD/ADHD with 100% accuracy. Although this node was small (n=5), it demonstrates the clinical utility of caregiver-reported cognitive impairment. The PIC-2 decision tree in the current study shows that although
increased levels of somatic complaints are more suggestive of ADHD, the addition of
significantly elevated caregiver report of cognitive impairment allows for extremely
accurate FASD/ADHD diagnosis, at least for this sample.

Terminal nodes 9 and 10 were created from Somatic Concern scores over 54 and
Family Dysfunction scores above 53. These two terminal nodes were further split by a
score of 77.5 on the Impulsivity and Distractibility adjustment scale. Although the
terminal nodes were split according to the Impulsivity and Distractibility score, both
nodes were classified as ADHD. Terminal node 9 contained scores below 77.5 and was
96% accurate and terminal node 10 had scores above 77.5 and was 74% accurate. These
results indicate that increased levels of family discord seem to be more closely associated
with an ADHD diagnosis. This relationship seems to hold regardless of the severity of
impulsivity and distractibility. These results are consistent with prior research showing
that family conflict and discord are common in families of children with ADHD. In fact
research has shown parents of children with ADHD experience more stress than parents
of children with other clinical disorders (Kaplan et al., 1998; Pressman et al., 2006).

Overall, it appears that specific patterns of performance on the WISC-IV subtests
and the PIC-2 adjustment scales have clinical utility in differentiating children with
FASD/ADHD and children with ADHD. Regarding the WISC-IV CART analysis, the
primary differentiating variable was the WISC-IV Information subtest; however the
accuracy of the decision tree was greatly enhanced with the addition of the
Comprehension, Block Design, Coding, Picture Concepts, and Similarities subtests. The
primary variable differentiating the groups for the PIC-2 CART was the Somatic Concern
adjustment scale. The addition of the Cognitive Impairment, Reality Distortion, Social
Skills Deficits, and Impulsivity and Distractibility scales resulted in accurate classification of the two groups.

In conclusion, it seems that the WISC-IV and the PIC-2 are able to accurately differentiate between children with FASD/ADHD and children with ADHD. These findings are significant because the high level of comorbidity between FASD and ADHD makes differential diagnosis an onerous task. The results of the CART analyses provide a clinical tool to assist in the differential diagnosis through the use of respected measures of cognitive and personality functioning. The need for clinical tools becomes vital in differential diagnosis when prenatal alcohol exposure is unknown or unquantifiable. The current findings reveal the addition of objective measures of cognitive and personality functioning in the diagnostic process could lead to increased accuracy of diagnosis.

**Limitations and Delimitations of the Study**

There were several limitations in the current study. The first limitation of the study is that the participants in the study were drawn from a population referred for a neuropsychological evaluation, suggesting that they were exhibiting significant deficits in several areas of potential functioning, which likely limits the degree to which the current results can be generalized to non-referred FASD and ADHD populations. An additional threat to external validity is the participants in the current study were evaluated at a Midwestern city and came from rural, suburban, and urban areas surrounding the city, which is likely not representative of the general United States population.

Another limitation of the current study is related to teratogen exposure. Although all of the children diagnosed with FASD in the current study had confirmed prenatal alcohol exposure, exposure to other teratogens was unknown. This presents the potential
for group differences to be attributable to possible confounding variables as several substances are known to be teratogenic with cognitive sequelae. For example, prenatal lead exposure has been linked with behavioral dysregulation and antisocial behavior. Additionally, maternal tobacco use during pregnancy has been linked to decreases in global cognitive functioning, increases in behavioral and emotional disturbance, and higher rates of attention deficits (Motlagh et al., 2011; Rice & Barone, Jr., 2000). Even prenatal exposure to prescription medications, such as antiepileptic medication has been linked with decreases in global cognitive functioning (Meador et al., 2009). Furthermore, the exact amount and pattern of prenatal alcohol exposure for the participants in the current study was unknown. Both of these limitations pose a threat to internal validity as the deficits reported in the current study may be attributable to confounding variables. A further limitation of the study is that the data were drawn from an archival database. A limitation of archival data is that access to potential confounding variables may be inaccessible for analysis. Another limitation of using archival data is the increased risk for transcription errors as the data were transferred from the source, to data collection sheets, and then into an electronic database.

Although there are limitations inherent in the current study, there are also multiple delimitations, which enhance the utility of the current study. A delimitation of the current study is sample sizes of the groups used. Specifically, the current study was comprised of 67 children in the FASD/ADHD group and 115 children in the ADHD group. It is uncommon to have access to this many participants who have been diagnosed with FASD, thus increasing the external validity of the current study. A strength of the current study is the use of current measures of personality and cognitive functioning.
Although previous research has examined the personality and cognitive functioning of children with FASD and ADHD, these studies are limited by the obsolescence of the measures used in the studies. The current study used the current editions of the WISC and PIC to examine cognitive and personality functioning. The use of current measures maximized the clinical utility of the present findings.

An additional delimitation of the current study is the use of the 4-Digit Diagnostic Code for diagnosing FASD, which provides a respected, objective measure of making an FASD diagnosis (Astley, 2004). The use of the 4-Digit Diagnostic Code increases the reader’s confidence in the authenticity of the diagnosis. Additionally, all of the participants in the current study were diagnosed with ADHD, Combined type by a licensed psychologist, thus increasing the consistency of the diagnoses across participants. Furthermore, this addresses concerns about differing underlying neuropsychological deficits among different ADHD subtypes (Chhabildas et al., 2001).

**Directions for Future Research**

The directions for further research are reported to improve upon the limitations reported in the current study and to encourage the continued investigation into unanswered questions regarding the functioning of individuals with FASD. The first suggestion relates to limitations of generalizability that were present in the current study. Specifically, the population from which the sample was drawn limited external validity. Therefore, it would be useful for future research to investigate cognitive and personality functioning with a sample more representative of the United States population. Additionally, the addition of non-referred participants with FASD and ADHD would likely improve the generalizability of the results.
An additional suggestion would be to conduct studies with greater control on potential confounding variables, including exposure to other teratogens. Specifically, investigations controlling for additional teratogen exposure would allow for greater confidence in the effects of prenatal alcohol exposure on the deficits and differences found in the study. Furthermore, future research should focus on investigating cognitive and personality functioning in different age ranges to determine if similar patterns are found. This had important implications for early intervention for younger populations and for intervention development for the adult population.

Another suggestion for future research is replication of the current study. Although the current results have documented the utility of the WISC-IV and PIC-2 in differentiating children FASD/ADHD and children with ADHD, these results need to be replicated to further clarify the clinical utility of these measures in differential diagnosis.

**Conclusion**

The current study utilized current psychological measures to investigate cognitive and personality differences in children with FASD/ADHD and children with ADHD. Investigation into the relationship between the WISC-IV and the PIC-2, which were used in the current study, revealed they were not significantly related to each other, indicating that each measure provided unique and useful information to the investigation. Furthermore, this lack of significance revealed the importance of personality measurement in the evaluation of children with FASD and ADHD, as personality functioning could not be inferred from cognitive functioning. Despite the limitations of the study, some very clear results emerged regarding cognitive and personality profiles, as well as differences in cognitive and personality functioning between the groups. The
results from this study revealed that both the FASD/ADHD and ADHD groups exhibited cognitive and personality deficits relative to the normative sample; however, the magnitude of cognitive impairment was greater for FASD/ADHD group even with the exclusion of individuals with mental retardation. A measure of personality functioning also revealed that impairment was common for both groups, though statistical analysis revealed that the groups contained statistically significant differences across personality domains.

The cognitive profile of the FASD/ADHD was characterized by processing speed and working memory deficits, as well as a relative weakness in verbal processing relative to visual-spatial abilities. The personality profile of the FASD/ADHD group was notable for elevations on the Cognitive Impairment, Impulsivity and Distractibility, Delinquency, Reality Distortion, Psychological Discomfort, and Social Skills Deficits adjustment scales. The variables that most greatly differentiated the groups were the Comprehension, Picture Concepts, Information, Matrix Reasoning, and Letter-Number Sequencing subtests on the WISC-IV, and the Cognitive Impairment, Somatic Concern, and Family Dysfunction adjustment scales on the PIC-2. These findings regarding specific areas of differences between the groups should be used to develop unique interventions for individuals with FASD that account for their specific pattern of strengths and weaknesses.

The current study also made great strides in increasing the accuracy in the development of a clinical decision tree to assist in differential diagnosis. Specifically, the current study revealed that specific patterns of performance on the WISC-IV and the PIC-2 could be used to accurately differentiate the groups although limitations exist when
extrapolating these results to other populations. These findings provide hope for the use of common clinical measures in the future diagnosis of FASD.

Overall, the results of the current study outline the many similarities and differences between individuals with FASD/ADHD and ADHD. It appears that cognitive and personality functioning are areas of common impairment for both groups. However, both groups do not exhibit the exact pattern or magnitude of deficits. These differences between the groups are important to elucidate in order to inform intervention development and to assist in differential diagnosis. Without additional research into the unique functioning of both groups, children with FASD may continue to be overlooked or misdiagnosed as having ADHD.
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