Sensory Processing and Integration and Children with Alcohol-Related Diagnoses: An Exploratory Analysis

Tracy L. Jirikowic

A dissertation submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

University of Washington

2003

Program Authorized to Offer Degree: Department of Education

UMI Number: 3091015

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

University of Washington
Graduate School

This is to certify that I have examined this copy of a doctoral dissertation by

Tracy L. Jirikowic

and have found that it is complete and satisfactory in all respects,
and that any and all revision required by the final
examining committee have been made.

Chair of Supervisory Committee:

Douglas Cheney
____
Douglas Cheney

Reading Committee

Douglas Cheney
____
Douglas Cheney

Deborah Kartin
____
Deborah Kartin

Scott Stage
____
Scott Stage

Date: 5/29/03

University of Washington

Abstract

Sensory Processing and Integration and Children with Alcohol-Related Diagnoses: An Exploratory Analysis

Tracy L. Jirikowic

Chair of the Supervisory Committee:
Associate Professor Douglas Cheney
Department of Special Education

The purpose of this study was: 1) to examine sensory processing and integration in young children with alcohol-related diagnoses to determine if there were differences in performance when compared to a group of typically developing children; 2) to explore the relationships between selected measures of sensory processing and integration with measures of early school performance and adaptive behavior; and 3) to determine which, if any, sensory processing, adaptive behavior, and school performance variables discriminated between children with and without alcohol-related diagnoses.

Twenty-five children with alcohol-related diagnoses were compared with 26 children with typical development matched for age, gender, and race/ethnicity on a battery of standardized tests that measured the following: 1) sensory processing, 2) sensory-motor performance, 3) school performance, and 4) adaptive behavior. Participants were 5 years to 8 years 6 months of age enrolled in preschool through second grade.

Results suggested that children with alcohol-related diagnosis performed significantly different from and more poorly than children with typical development on 10 of 13 primary variables. The performance of children with alcohol-related diagnoses

was also more frequently classified in categories that indicated sensory processing and motor concerns, as well as behavior problems based on teacher and caregiver ratings. Findings from a discriminant function analysis suggested that measures of sensory processing, sensory-motor performance, math abilities, adaptive behavior and problem behaviors most consistently discriminated between these two groups of children. There were moderate positive relationships between several sensory-motor variables and math performance, adaptive behavior, and problem behaviors.

Results provide evidence of dysfunction in sensory integration, in addition to other behavioral and academic deficits in children with alcohol-related diagnoses. Such factors should be considered when assessing the neurobehavioral function and educational performance of young children with alcohol-related diagnosis. Replication of these findings and further investigation of interventions and outcomes based on a sensory integration framework are warranted.

TABLE OF CONTENTS

Page

List of Tables

Acknowledgements

I would like to express my deepest gratitude to all the people who supported this endeavor.

To the members of my advisory committee, Deborah Kartin, Doug Cheney, Scott Stage, Heather Carmichael-Olson, and Susan Sandall. Thank you for your invaluable encouragement and guidance.

To Kim Van Den Wymelenberg and Meredith Luethe. I am forever grateful for your assistance (and patience) with data collection.

To my colleagues at the University of Washington FAS-DPN. I sincerely appreciate all that you have taught me, as well as your professionalism, compassion, and dedication to this work

To the families and children who will continue to be our teachers.

This research was partially funded by a grant from the U.S. Department of Education (Preparation of Leadership Personnel); No. H029D970035, CFDA #84.029D. " Preparing Leaders for Careers in Transdisciplinary Professional Development, Research, and Administration in the Education of Children with Disabilities."

Dedication

To my parents and MLB for their love and support.

Statement of the Problem

Alcohol is a neurobehavioral teratogen. Prenatal exposure to alcohol has a wide range of effects on the developing brain and central nervous system. Potential effects include primary problems such as language and motor deficits, poor memory, attention, and cognitive processing (Mattson & Riley, 1998; Streissguth, Barr, Sampson, & Bookstein, 1994). Secondary problems such as school failure, poor adaptive behavior, and long-term difficulties with employment and independent living have also been associated with prenatal alcohol exposure (Streissguth, Barr, Kogan, & Bookstein, 1996).

Fetal alcohol syndrome (FAS) and other alcohol-related birth defects may result from alcohol exposure in utero. Fetal alcohol syndrome (FAS) is a medical diagnosis based on evidence of prenatal exposure to alcohol, growth deficiency, characteristic facial features and central nervous system dysfunction (Astley & Clarren, 1999; Clarren & Smith, 1978; Jones & Smith, 1973). Individuals with a history of prenatal alcohol exposure who do not present with all of the features of FAS, but demonstrate complex behavioral or cognitive abnormalities may be diagnosed with other alcohol related conditions [e.g. fetal alcohol effects (FAE), alcohol-related neurodevelopmental disorders (ARND), fetal alcohol syndrome spectrum disorder (FASD)]. It is estimated that the prevalence of FAS ranges from 0.6 to 3 per 1,000 live births (Institute of Medicine, 1996). The prevalence of all alcohol-related diagnoses may be as high as 6 per 1,000 births (Institute of Medicine, 1996). FAS has been referred to as the leading known cause of mental retardation in the western world (Abel & Sokol, 1987) with a prevalence cited as greater than that of other neurodevelopmental birth defects such as spina bifida or Down Syndrome (Burgess, Lasswell, & Streissguth, 1992).

While impaired intellectual abilities, learning, and behavior problems have been consistently reported in the literature, the manifestations of prenatal alcohol exposure in each individual vary considerably. Children affected by prenatal alcohol exposure often demonstrate a wide range of neurobehavioral problems whether or not they display the characteristic physical features of FAS (Astley, 2000; Astley & Clarren, 1999; Mattson, Riley, Gramling, Delis, & Jones, 1998). Damage from prenatal alcohol exposure is often described on a continuum from severe, to subtle, diffuse, and difficult to recognize (Astley & Clarren, 1999). Many underlying learning difficulties related to prenatal alcohol exposure and CNS dysfunction may be easily overlooked or misunderstood. For example, children who are not mentally retarded, or children without the characteristic facial features of FAS, typically have no "visible" indicators underlying CNS dysfunction. Subsequently, many children affected by prenatal alcohol exposure may not carry an alcohol-related diagnosis, or they may not meet eligibility criteria for supportive educational, health, disability or social services (Olson, Morse, & Huffine, 1998). However, they may still present with or be at risk for subtle neuropsychological or cognitive deficits that can significantly impact the development of age-appropriate academic, social, and adaptive-behavioral function (Roebuck, Mattson, & Riley, 1999).

The U.S. Department of Education has identified children exposed to alcohol as a group of children in need of academic interventions and improved school-related outcomes (U.S. Dept of Education, 2000). Occupational therapists, educators, and other related service personnel working in the schools must understand and be better prepared to meet the learning and developmental needs of children with FAS and alcohol-related conditions. Understanding the impact of prenatal alcohol exposure on learning and development is an important element of responsive and successful intervention programming (Burgess et al., 1992; Connor & Streissguth, 1996; Morse & Weiner, 1994; Olson et al., 1998). In addition, early recognition and diagnosis of FAS and alcohol-related conditions has been related to increased odds of fewer secondary disabilities throughout the lifespan (Streissguth et al., 1996; Streissguth, 1997).

Although early recognition and intervention have been described as protective factors in the development of children with prenatal alcohol exposure, best practices in diagnosing, assessing and intervening with young children with alcohol-related conditions are still being debated (Interagency Coordinating Committee on Fetal Alcohol Syndrome, 2000). Despite research evidence that suggests prenatal exposure to alcohol yields a range of neurobehavioral difficulties across most domains of development (Barr, Streissguth, Darby, & Sampson, 1990; Coles et al., 1991; Harris, Osborn, Weinberg, Loock, & Junald, 1993; Mattson & Riley, 1998), research findings are less consistent among younger children (Chandler, Richardson, Gallagher, & Day, 1996; Fried & Watkinson, 1990; Greene et al., 1991; Larrouque et al., 1995;). Factors such as normal developmental variation and neuromaturation, the impact of the physical and social environment, sensitivity of test instruments, the variability in the degree of alcohol exposure, and the diagnostic criteria used to describe children with FAS or prenatal alcohol exposure in each study, contribute to the inconsistent findings and difficulties with the reliable identification of the effects of prenatal alcohol exposure on young children's development (Chandler et al., 1996; Jacobsen et al., 1993). Clearly, a better understanding of the impact of prenatal alcohol exposure on early neurobehavioral function remains an important step towards improving the developmental outcomes of children with FAS and alcohol-related conditions.

Sensory processing and integration is one area of neurobehavioral function that has not been adequately explored in children with prenatal alcohol exposure. Yet, impaired sensory processing and integration have been theoretically linked to a wide range of neurobehavioral difficulties that involve attention, coordination, learning, and emotional functioning (Ayres, 1972, 1979; Dunn, 1997; Parham & Mailloux, 2000; Wilbarger & Wilbarger, 1991, 2001). Sensory integration (SI) is a general term that refers to the behavioral responses and neurological processes that organize sensation from the body and the environment. These responses and processes make it possible for a child to function effectively by responding adaptively to the changing sensory demands of the environment (Ayres, 1979). Efficient sensory integration is believed to be an important foundation for higher-level learning, adaptive behavior, and social-cognitive functioning among children (Ayres, 1972; Bundy & Murray, 2002; Parham & Mailloux, 2001).

Parents of children with dysfunction in sensory integration frequently report symptoms such as poor coordination, clumsiness, hypersensitivity to sensory stimuli, as well as social and learning difficulties (Parham & Mailloux, 2001). These symptoms have also been reported by caregivers of children with alcohol-related diagnoses (Astley, 2000). However, to our knowledge, only one study to date has systematically analyzed sensory processing and integration and related behaviors in children with alcohol exposure (Morse, Miller, & Cermak, 1995). Although this study provides preliminary evidence that suggests children with FAS and alcohol-related conditions present with sensory processing and integrative difficulties, the underlying SI deficits must be more clearly documented before intervention can be appropriately recommended and designed, and the effectiveness of the intervention can be measured. A comprehensive study of sensory processing and integration in children with alcohol-related conditions, as well as, how these responses and processes potentially relate to behavior, learning, and social difficulties, is an important first step in our understanding of SI problems among this population of children.

The purposes of this study are the following: (a) To examine sensory processing and integration in young children with alcohol-related diagnoses to determine if there are patterns and significant differences in performance when compared to a group of children who are typically developing, (b) To explore the relationships between selected measures of sensory processing and integration with measures of early school performance and adaptive behavior, (c) To determine the degree of impact dysfunction in sensory integration may have on early school performance and adaptive behavior in children with and without alcohol-related diagnoses.

Examining sensory processing and integration, and the potential impact of SI dysfunction on school performance and adaptive behavior may help educators, therapists, and caregivers better understand of some of the neurobehavioral difficulties common among children with alcohol-related conditions. Such information also has implications for assessment, educational programming, intervention planning, and perhaps, the prevention of later secondary disabilities.

Literature Review

The Developmental Sequelae of Prenatal Alcohol Exposure

The first part of this literature review will discuss the effects of prenatal alcohol exposure on human development. The teratogenic impact of alcohol on the fetus will be described, followed by a review of current diagnostic terminology. Current findings related to CNS dysfunction, primary neurobehavioral disabilities, and associated secondary educational, behavioral and social problems will be reviewed. The impact of alcohol exposure on the sensory-motor development of young children will also be highlighted.

Teratogenic Effects of Alcohol.

There is clear evidence from human and animal literature that prenatal alcohol exposure has long-term and detrimental effects on the developing brain and central nervous system (CNS) (Guerri, 1998; Mattson & Reilly, 1998). The extent of CNS damage is largely dependent upon the dose, timing, and pattern of alcohol exposure in utero. In general, greater frequencies and amounts of alcohol consumption during pregnancy are associated with greater risks of damage to the developing fetus (Institute of Medicine, 1996). Genetics, co-exposure with other teratogens, and the postnatal environment, however, also influence individual susceptibility to damage from prenatal alcohol exposure and the potential effects on later neurobehavioral development (Astley & Clarren, 2000; Bagheri, Burd, Martsolf & Klug, 1998).

In general, higher doses of alcohol consumed by the mother are related to higher risks of mental retardation, as well as increased severity of motor, cognitive, and neurobehavioral deficits (Jacobson et al., 1993; Streissguth, Sampson, & Barr, 1989; Streissguth et al., 1994). Regarding the timing of exposure, maternal alcohol use during the first trimester of pregnancy is associated with higher risks of organ (e.g. heart, or kidney), musculoskeletal (e.g. dysmorphic facial features, minor physical and bone deformities), and structural CNS abnormalities (Institute of Medicine, 1996). Exposure during the second and third trimesters is associated with higher risks of CNS deficits but is less related to structural abnormalities, or growth retardation (Institute of Medicine, 1996). The pattern of exposure also affects later stages of fetal development. Patterns of binge drinking that result in higher maternal peak blood alcohol concentrations (BAC) are associated with greater levels of damage to the fetus when compared to more moderate levels of social drinking and lower BAC concentrations (Streissguth, 1997). No amount of alcohol, however, is considered to be truly safe and no specific amount or pattern of alcohol exposure has been equated with absolute or predictable levels of fetal damage.

Diagnosis of FAS and Alcohol-Related Conditions.

Fetal alcohol syndrome (FAS) is a medical diagnosis based on growth deficiency, characteristic facial features, central nervous system dysfunction and evidence of fetal exposure to alcohol (Astley & Clarren, 1999; Jones & Smith 1973). The characteristic facial features associated with FAS include short palpebral fissures (small eye relative to the space between the eye), a thin upper lip, and a smooth philtrum (the area between the nose and lips). Indicators of growth deficiency include height and weight measures of less than the 5th to 10th percentile for age. Indicators of CNS dysfunction include the presence of hard neurologic signs such as microcephaly, an abnormal imaging scan of the brain, (e.g., indicating changes in the size or structure of the brain) or the presence of seizures. In the absence of structural abnormalities, CNS dysfunction is often evidenced by psychometric findings that suggest a range of motor, cognitive, attention and/or language deficits (Astley & Clarren, 1999). Confirmed evidence of alcohol consumption during pregnancy is also essential for accurate diagnosis.

The diagnosis of FAS represents one point on the continuum of possible effects related to prenatal alcohol exposure. Not all children exposed to alcohol are diagnosed with FAS. Fetal alcohol effects (FAE), possible fetal alcohol effects (PFAE), alcohol related neurodevelopmental disorders (ARND), alcohol related birth defects (ARBD), and fetal alcohol syndrome spectrum disorder (FASD) are terms that have been used to describe alcohol-related effects in children who do not meet the diagnostic criteria for FAS. Even though children with these diagnoses do not meet the full criteria for FAS, they may still manifest many of the cognitive and behavioral effects related to CNS dysfunction (Aase, Jones, & Clarren, 1995; Astley & Clarren, 1999). For the purpose of this study, the term/s "FAS and alcohol-related diagnoses" will be used to refer to children with FAS and full the range of diagnosed alcohol effects unless otherwise specified.

<u>The Effects of Prenatal Alcohol Exposure Across the Lifespan.</u>

A continuum of problems has been reported in individuals with prenatal alcohol exposure from infancy through adulthood. Although alcohol causes permanent damage to the CNS, problems may emerge and manifest themselves differently as the child moves through different stages of growth and development and, indeed, as higher-level brain functioning matures. It is not uncommon for children affected by prenatal alcohol exposure to present with apparently normal developmental profiles in infancy and only later demonstrate learning and behavior problems as they reach school age (Olson et al, 1998). For this reason, a lifespan perspective is essential. It is also important to acknowledge the multitude of prenatal and postnatal factors within the child's environment that collectively impact the child's development. For example, negative environmental factors (e.g., abuse, neglect, family instability) can exacerbate and further contribute to developmental problems, whereas positive protective factors such as a stable, loving home environment may mitigate some of the effects of prenatal alcohol exposure (Streissguth et al., 1996).

Neuroanatomical and Neurophysiological Findings.

Neuroimaging studies, autopsy, and animal studies provide evidence of the teratogenic effects of prenatal alcohol exposure on the CNS. Children affected by prenatal alcohol exposure do not, however, consistently demonstrate the same patterns of structural damage and many children with prenatal alcohol exposure show no evidence of structural damage. A review by Roebuck, Mattson, and Riley (1998) summarized evidence of structural damage related to heavy alcohol exposure in the corpus collosum, basal ganglia, anterior vermis, and cerebellum. These findings were based on reviews of autopsy and magnetic resonance imaging (MRI) studies in humans. Guerri (1998) further described the CNS deficits related to prenatal alcohol exposure at three levels; structural, cellular, and neurochemical. In her review, which included both human and animal studies, evidence of primary structural damage in the neocortex, hippocampus and cerebellum was noted. At the cellular level, changes in the processes of several neuronal mechanisms such as proliferation, migration, cell growth, and differentiation were evidenced, all of which are important components of healthy CNS development in utero. Finally, neurochemical changes in neurotransmitter systems that mediate various neurobehavioral functions were reported. These changes included decreases in certain neurotransmitters, uptake sites, and classes of receptors. Alterations in neuroendocrine functions that mediate stress responses and have modulatory effects on behavior were also associated with prenatal alcohol exposure in animals and humans.

Although these studies and subsequent reviews provide evidence of CNS changes related to prenatal alcohol exposure, more research is needed to clarify relationships between specific structural and neurochemical deficits and functional neurobehavioral findings. Furthermore, many of the studies (e.g. those using autopsies) were completed on children most severely affected by alcohol and thus they reflect the extreme end of the continuum. It appears that many children with prenatal alcohol exposure show no evidence of structural damage with current imaging techniques, (or evidence of mental retardation), yet they display a wide range of neurobehavioral problems suggestive of underlying organic brain damage (Astley & Clarren, 1999).

In the absence of severe structural abnormalities or mental retardation, some more sophisticated imaging studies have detected differences in certain areas of the brain, which may reflect the more subtle and diffuse changes in brain function often associated with prenatal alcohol exposure and aberrant neurobehavioral performance. For example, Clark, Li, Conry, Conry, and Loock (2000) analyzed the neuroimages of nineteen individuals who met the criteria for FAS but did not demonstrate severe cognitive dysfunction (mean full scale IQ = 80). Results indicated that only one individual demonstrated structural brain abnormalities. However, when CNS metabolic rates were analyzed in comparison to a control group of individuals exhibiting typical development, findings indicated significant differences in the subcortical areas of the thalamus, which functionally serve as a sensory relay to the cortex; and areas of the basal ganglia, associated with the control and coordination of movement. Findings from this particular study, although preliminary, suggest evidence of subtle brain differences that potentially impact sensory and motor functions, (an area of relevance to this study) in the absence of severe cognitive or structural impairment.

Neurobehavioral Findings: Primary Disabilities.

The use of the term "primary disabilities" provides a framework for understanding the performance and learning deficits directly associated with prenatal alcohol exposure and CNS damage. Many studies have described the learning and behavioral profiles of children with FAS and prenatal alcohol exposure. Mattson & Riley (1998) summarized twenty years of case and group studies. In general, deficits of varying degree associated with prenatal alcohol exposure were noted across the domains of intelligence, activity level and attention, learning and memory, motor and visuospatial functioning. However, caution is in order when generalizing these conclusions. Issues that need to be considered include the lack of a standardized diagnostic criterion for FAS and, in particular alcohol-related conditions, the variable amounts of alcohol exposure reported in each study, as well as inconsistent controls for other pre-and postnatal factors such as socioeconomic status (SES), childhood abuse or neglect, etc.

Children with prenatal alcohol exposure demonstrate a wide range of cognitive abilities. Variable performance on intelligence tests, from the normal range to severe mental retardation, has been described (Mattson & Riley, 1998; Streissguth et al., 1996). Individuals with a diagnoses of FAS seem to demonstrate poorer cognitive performance that those with a diagnoses of FAE (Boyd, et al Conry, 1991). For example, in a large clinical sample of 473 individuals with FAS and FAE the overall IQ performance for individuals with FAS was in the low average range (M =79; range of 20 to 129), and within an average range for individuals with FAE (M = 90; range 42 to142) (Streissguth et al., 1996).

Specific cognitive deficits commonly described in children with prenatal alcohol exposure include poor memory, learning, and visual-spatial skills, as well as problems in executive functioning (e.g. planning, abstract reasoning, and problem solving) (Mattson & Riley, 1998). In addition, academic achievement and adaptive behavior are often reported to be considerably lower than one would expect based on intelligence measures (Streissguth et al., 1996). Cognitive deficits may not be readily identified in early childhood, but can emerge during school age as higher-level cognition develops and environmental and academic demands increase and become more abstract (Burgess & Streissguth, 1992).

Poor attention and high activity levels have frequently been reported as hallmark features of prenatal alcohol exposure. These problems may be recognizable in infancy and appear to persist throughout childhood. Infants with prenatal alcohol exposure have been described as jittery, irritable, and hyperalert (Eyler & Behnke, 1999). Impulsive, distractible, and "always on the go" further describe the behaviors of children with prenatal alcohol exposure in the preschool and elementary years (Janzen, Nanson & Block, 1995). Attention deficits with and without hyperactivity have been reported in older children affected by alcohol exposure (Coles et al., 1991; Streissguth et al., 1994). It is important to note that some researchers have highlighted similarities between children with attention deficit disorder (ADD) and FAS or alcohol related diagnoses (Nanson & Hiscock, 1990) while in carefully controlled conditions others have found discernable differences between the neurocognitive and behavioral profiles of children with ADD and children with FAS (Coles et al., 1997).

Learning and academic problems have been widely described in children with prenatal alcohol exposure. Poor achievement in mathematics has been a persistent finding in a sample of children with prenatal exposure followed prospectively at 7 and 14 years of age (Streissguth, Barr, & Sampson, 1990; Streissguth et al., 1994). Poor academic performance as rated by teachers, poor spelling achievement, decreased spatial and verbal memory, and speed of information processing have also been reported (Olson, Sampson, Barr, & Bookstein, 1992). In addition, a variety of speech, language, and communication problems have been described that include delays in speech acquisition, impaired receptive and expressive language, and problems in speech production (Church & Kaltenbach, 1997). Research also suggests that some children affected by prenatal alcohol exposure demonstrate a discrepancy between their verbal abilities and their capacity to use these skills effectively in social communication, which is an important foundation for developing social relationships and exchanging information (Coggins, Friet, & Morgan, 1998).

Motor Development

Motor difficulties are also described as a primary neurobehavioral effect of prenatal alcohol exposure. Osborn, Harris, and Weinberg (1993) reviewed the early literature on case and group studies and summarized the neuromotor outcomes of children with alcohol exposure. Deficits were noted in infancy and throughout childhood. Associated problems included fine and gross motor delays, gait abnormalities, balance, and visual-motor deficits. Some studies described severe neuromotor delays and cerebral palsy in children with prenatal alcohol exposure. More commonly, children presented with mild to moderate motor delays, and poor quality performance characterized by decreased speed, efficiency, and control of movement. More specific details describing the sensory-motor development of young children with alcohol-related conditions can be found in a later section of this paper.

Studies on motor development in alcohol-exposed infants have yielded mixed findings. Several researchers have described developmental motor delays in infants as measured by standardized tests such as the Bayley Scales of Infant Development (Autti-Ramo & Granstrom, 1991; Jones, Smith, Ulleland, & Streissguth, 1973). Other motor difficulties described include poor eye-hand coordination, tremulousness and weakened grasps (Harris et al., 1993). Some researchers found clinically significant effects on motor performance only with infants at high exposure levels (Jacobsen et al., 1993). In children with lower levels of exposure, however, these authors also reported qualitative differences in the ability to imitate, stand, and walk when compared to children without alcohol exposure. Other researchers have found no effects of prenatal alcohol exposure on infant motor or mental development (Richardson & Day, 1991).

Motor deficits that have been reported in older children with FAS or prenatal alcohol exposure include difficulties with fine motor, gross motor (Barr et al., 1990; Harris et al., 1993; Mattson et al., 1996), and visual motor abilities (Janzen et al., 1995). Decreased gross motor performance on tasks associated with balance has also been reported (Roebuck, Simmons, Richardson, Mattson, & Riley, 1998). Low average motor performance on standardized tests has been found in school-aged children, with qualitative performance described as lacking adaptability, economy, and speed of performance (Kyllerman et al., 1985).

Despite reports of poor motor performance among older children with prenatal alcohol exposure, results are inconsistent and some authors report no significant findings. Chandler et al. (1996) found no effects on gross motor development in marijuana and alcohol-exposed 3-year-olds. Two studies that used the McCarthy Scales of Children's Abilities found no significant relationship between prenatal alcohol exposure and the motor development of preschool children (Larrouque & Kaminski, 1995; Fried & Watkinson, 1990). Additionally, Admans and colleagues (2001) found differences on measures of eye-hand coordination, but no differences in gross motor development in 6- to 8-year-old children with FAS. The discrepancy in such findings has been attributed to factors such as the cessation of alcohol use by the 2nd trimester of pregnancy (Chandler et al., 1996), low to moderate amounts of alcohol exposure in the study group, or the problems in the sensitivity of certain standardized measures (Jacobson et al., 1993).

Neurological Soft Signs

Children with prenatal alcohol exposure also demonstrate evidence of minor neurological soft signs. The presence and persistence of neurological soft signs suggest CNS immaturity or minor neurological dysfunction presumably to be related to later learning and behavioral difficulties (Spreen, Rissser, & Edgell, 1995). Marcus (1987) reported soft signs on neurological examination that included a clumsy and wide-based gait, dysdiadochokinesis, tremors, and axial ataxia in five case reports of children with FAS. A significant relationship was found between prenatal alcohol exposure and the presence of minor neurologic soft signs in preschool children with moderate levels of alcohol exposure (Larrouque & Kaminski, 1998). Higher rates of neurological soft signs have also been noted in children with FAS when compared with other alcohol related conditions, along with increased scores on other measures of CNS dysfunction (Jirikowic, unpublished data).

Using neurological soft signs as a measure of CNS function, however, merits caution. There is evidence of moderate relationships between the persistence of soft signs and later learning disabilities, psychopathology, and other neurobehavioral difficulties (Spreen et al., 1995). Yet, children who are typically developing also demonstrate moderate rates of neurologic soft signs or immaturities, which may developmentally persist until 8 or 9 years of age (Ardilla & Roselli, 1996; Mutti, Sterling, Martin, & Spalding, 1998). Therefore, because soft signs may disappear with age and they are not always a clear indicator of disability, the usefulness of neurological soft signs has been questioned, despite their purported advantage as a marker of CNS integrity and an assessment that may be less impacted by the sociocultural environment (Larrouque & Kaminski, 1998).

Behavior Problems

Prenatal alcohol exposure has been associated with a continuum of long lasting behavioral and functional deficits. Difficult behaviors have been cited as an overarching concern among children with prenatal alcohol exposure throughout the lifespan (Steinhausen & Spohr, 1996). Behavioral and psychosocial problems have been reported in children prenatally exposed to alcohol with and without the full spectrum diagnosis of FAS (Olson et al., 1998; Roebuck et al., 1999; Steinhausen & Spohr).

Behavior problems are often cited as one of the primary reasons that families seek diagnosis or treatment. Adaptive and social behaviors are reported as inconsistent with age and intellectual levels (Streissguth et al., 1996; Thomas, Kelly, Mattson, & Riley, 1998). Although there is evidence that some behavior problems are identifiable early on, many behavior and social problems emerge and increase as the child gets older (Whaley, O'Connor & Gunderson, 2000). Many of these problems are considered secondary to learning problems or underlying CNS dysfunction that has been undiagnosed, misunderstood, or ignored. Although several problematic behaviors may be manifestations of underlying CNS dysfunction, other factors such as poor environment, family dysfunction, SES, biological (genetic) or postnatal influences also complicate behavioral profiles (Institute of Medicine, 1996). Regardless of the etiology of these behavioral and functional deficits, however, it is important to acknowledge the persistence of these problems among children with a history of prenatal alcohol exposure and the subsequent impact on caregivers and others in the child's life.

Behaviors frequently reported as problematic include those stemming from attention and hyperactivity, to emotional lability, impulsivity, aggression and poor organization, and poor social interactions (Coles et al., 1991; Janzen et al., 1995; Astley, 2000; Brown et al., 1991). While younger children have been described as engaging, and verbal, they seem to lack social boundaries (Olson, 1994). Some researchers have also reported stereotypic behaviors, similar to those reported among children with autism, in preschool children with FAS (Janzen et al., 1995). Older children with FAS and prenatal alcohol exposure are often described as socially immature with poor peer relationships and difficulty establishing and maintaining friendships (Roebuck, Mattson & Riley, 1999). Problems with both internalizing and externalizing (e.g. aggression, destructiveness and over activity) behaviors have also been reported (Coles et al., 1991). Difficulties with reasoning, organization, distractibility and persistence, as well as completion of simple tasks and coping with transitions and changes in routine have been described in later childhood and adolescence (Olson et al., 1994).

Secondary Disabilities

In many children affected by prenatal alcohol exposure, functional and behavioral deficits underlie a range of poor outcomes and secondary disabilities that include conduct problems, school failure, trouble with the law, and poor vocational abilities. Secondary disabilities are defined as deficits not directly attributable to CNS dysfunction, but rather are subsequent manifestations of underlying neurobehavioral problems that persist over time (Streissguth & Kanter, 1997). For example, alcohol exposure does not directly cause conduct problems or defiant behavior. Instead, the alcohol may have contributed to poor cognitive processing and memory, which makes it difficult to remember complex directions, anticipate the results of one's actions, or clearly understand consequences. Prenatal alcohol exposure likewise does not imply school failure, however, learning difficulties that are not properly understood can result in lower academic achievement, subsequent frustration, low self-esteem, and anger, which can further negatively impact performance or result in school drop out. In contrast, careful attention to strengths and extra support for limitations can contribute to the development of structured physical and social environments that may increase the likelihood of success at school, home, or in the community (Burgess et al., 1992; Kleinfeld & Wescott, 1993; Kleinfeld, Morse, & Wescott, 2000).

In general, long-term outcomes for many adolescents and adults with prenatal alcohol exposure who have been studied so far are poor, as they demonstrate persistent deficits in academic, social, vocational, and adaptive skills. However, outcomes are highly individualized and dependent upon many ecological factors. Individuals affected by prenatal alcohol exposure are reported to have high rates of secondary disabilities such as academic failure and school drop-out, difficulties with independent living, maintaining employment, managing money, trouble with the law, and engaging in satisfying relationships (Streissguth et al., 1996). They also demonstrate elevated risks for substance abuse and mental health problems (Streissguth et al.). Despite reports of challenging futures for children with alcohol exposure, anecdotal information and case studies provide evidence that timely interventions, structured physical and social environments, and a network of supportive professionals and caregivers can contribute to more positive adult outcomes (Kleinfeld & Wescott, 1993; Kleinfeld et al., 2000). Many individuals with FAS and alcohol-related diagnoses can and do live productive and satisfying lives (Kleinfeld et al.).

Sensory Integration: Theoretical Foundations

The second part of this literature review will describe the theoretical foundations of sensory integration and dysfunction in sensory integration as a framework for examining the neurobehavioral difficulties of children with alcohol-related diagnoses. Available research on prenatal alcohol exposure, sensory integration and related sensory motor development will be discussed. The rationale for studying sensory processing and integration in young children with alcohol-related diagnoses, as well as the educational relevance of this information, will be provided.

Sensory integration refers to the central processing and organization of sensory information from one's body and the environment for functional performance (Ayres, 1972). Sensory integration is also a theoretical framework widely used by pediatric occupational therapists in the schools and other clinical settings to understand the underlying causes of behavior and learning problems in children (Kimball, 1999; Parham & Mailloux, 2001). Sensory integration (SI) is believed to be an important foundation for higher-level social, cognitive, and motor development (Ayres, 1972; Dunn, 1997).

The theory of SI is based on information from child development, neurobiology, psychology, and education. SI has been a heavily researched area of occupational therapy practice (Parham & Mailloux, 2000), yet research findings have yielded mixed results and produced more questions than answers (Polatajko, Kaplan & Wilson, 1992). Due to its complexity, and the controversy surrounding this construct, SI as a theory and framework for understanding behavior and CNS dysfunction continues to evolve and undergo refinement.

The theoretical framework of sensory integration is complex. A basic postulate assumes that certain overt behavioral responses indicate underlying CNS functions. These functions involve the processing, filtering, and organization of multisensory information from tactile, vestibular-proprioceptive, taste, olfactory, visual, and auditory systems. Three additional assumptions are central to the theory of sensory integration: (a) individuals take in sensory information from the environment and from movement of their bodies, integrate this information within the CNS, and use this information to plan and organize behavior; (b) deficits in processing and integrating information within the CNS interfere with planning and producing behaviors related to efficient conceptual and motor learning; (c) opportunities for enhanced or carefully controlled sensory input within the context of meaningful activity can facilitate more efficient CNS processing and integration of sensory input, and thus, improve the planning and organization of adaptive behavior and enhance the ability to learn (Bundy & Murray, 2002).

Sensory integration is hypothesized to play an important role in normal development (Mailloux, 1997). Development from a sensory integrative perspective occurs as the CNS organizes increasingly complex information in order for the individual to generate more complex actions and adaptive behavioral responses (Ayres, 1972). Sensory integration begins during fetal development and continues throughout infancy and early childhood. Sensory integrative processes unfold as infants learn to attach meaning to the multitude of sensory stimuli received from the physical and social environment and use it for learning (Parham & Mailloux, 2001). The capacity to shift attention to meaningful stimuli and tune out what is irrelevant to current needs or tasks is also a part of the development of sensory integration (Ayres, 1972). These functions support the child's ability to organize behavior for increasing lengths of time, explore objects and surroundings in more sophisticated ways, and gain greater control of emotional regulation (Parham & Mailloux, 2001).

The third through seventh years are considered particularly important for sensory integration, as the child's evolving capacity to organize behavior continues to mature and provide the foundation for higher level-learning, cognitive, and interactive abilities (Mailloux, 1997). Based on extensive clinical observation and experience with standardized testing of sensory integration theory, Ayres (1972) concluded that most foundational sensory integrative abilities appear to mature by 7 or 8 years of age.

Dysfunction in Sensory Integration

Sensory integrative dysfunction refers to a heterogeneous group of symptoms that are thought to reflect subtle, primarily subcortical, neural dysfunction involving multisensory systems (Miller, Lane, & Hanft, 2000; Parham & Mailloux, 2001). The theory of sensory integrative dysfunction has its roots in nonspecific forms of brain deficiency (Ayres, 1972; Bundy & Murray, 2001). No specific neural mechanism has been identified as the cause of sensory integrative dysfunction. The theory assumes normal sensory reception at the peripheral level, with the breakdown of function occurring centrally, where the information must be interpreted, integrated, and organized for efficient use in learning and functional behavior.

Profiles of academic difficulties, attention problems, hyperactivity, emotional dysregulation, motor coordination, and/or balance disorders are commonly reported among children with dysfunction in sensory integration. Often behavioral, social and motor coordination problems are cited as primary areas of concerns and reasons parents seek evaluation of their child (Parham & Mailloux, 2001). Deficits in sensory integration have been described in a wide range of children with learning disabilities (Ayres, 1972; Parham, 1997), developmental disabilities and autism (Baranak, Foster, & Berskon, 1997; Miller, et al., 1999), attention deficit disorders (Mulligan, 1996), and motor incoordination disorders (Dahl Reeves & Cermak, 2002). While many of the behavioral and developmental profiles of children in each diagnostic category show some overlap (and sensory processing and integration difficulties cannot account for all symptoms that are manifested in each of these disorders), SI has been considered a useful framework for identifying, intervening with, and reframing children's learning and behavioral difficulties in the absence of severe CNS dysfunction or disability.

Terminology and Definitions

SI dysfunction clearly does not refer to one specific disorder but rather to a heterogeneous group of symptoms that are believed to result from inefficient CNS processing and organization of sensory information. The depth and complexity and of SI theory, in addition to the high degree of individual variability among developmental symptoms and behavioral profiles, has resulted in some confusion over evolving SI concepts as well as the use of inconsistent terminology in the literature. In an effort to clarify and unify terminology, and more systematically describe and discuss sensory integration concepts, Lane, Miller, and Hanft (2000) have presented working definitions of sensory integration (SI) and dysfunction in sensory integration (DSI). These definitions guide and refine our conceptualization and understanding of SI as a both a neurobehavioral process and theoretical framework. Definitions drawn from the work of these authors will be used in this paper to uniformly describe terms and concepts unless otherwise specified.

Sensory processing, like sensory integration, is an encompassing term that refers to the way in which the CNS and the peripheral nervous system manage incoming sensory information from the incoming peripheral sensory systems. The reception, modulation, integration and organization of stimuli, including the behavioral responses to sensory stimuli are all components of sensory processing. Sensory integration as a neurobehavioral process, therefore, becomes a component function of sensory processing (Miller et al., 2000).

Sensory processing and integration is the term that will be used in this paper to refer to the aforementioned CNS processes and neurobehavioral functions that involve awareness of sensation, modulation of sensation, and the ability to perceive qualities of sensory stimuli (e.g. intensity, duration). This term reflects the use of both contemporary and historical terminology.

Sensory integration will refer to the theoretical framework commonly used by occupational therapists to understand and treat neurobehavioral difficulties in children.

"Dysfunction in sensory integration (DSI) is the inability to modulate, discriminate, coordinate or organize sensation adaptively. DSI is a general term that implies a diminished ability to interact effectively or efficiently within the demands of one's culture, environment, relationships or tasks. There are three subtypes of DSI which include deficits in motor planning, sensory discrimination and sensory modulation (Lane, Miller & Hanft, 2000 p. 2)." The term DSI will encompass all three of these subtypes unless otherwise specified.

Dyspraxia is defined as difficulty planning and performing novel motor actions or a series of motor actions (Lane, Miller & Hanft, 2000). Praxis includes both motor and cognitive components and is further described as the ability to conceptualize, organize, and execute non-habitual motor tasks. When the term developmental dyspraxia is used in the SI literature, there is an assumption that motor performance difficulties are related to poor sensory processing (primarily vestibular-proprioceptive and tactile systems) and poor motor planning. Children with dyspraxia do not efficiently process sensory information about their bodies and movement, relative to their physical environment, in a manner that contributes to efficient motor learning and skilled motor actions (Dahl Reeves & Cermak, 2002; Missiuna & Polatajko, 1995).

Dyspraxia manifests itself primarily as developmental movement dysfunction (Giuffrida, 2001). However, dyspraxia is not the only underlying factor associated with developmental movement problems. Difficulties with motor control, "general clumsiness," and delays in motor skill acquisition are symptoms frequently documented among children with learning and developmental difficulties (Missiuna & Polatajko, 1995). Such non-specific motor difficulties have often been labeled as Developmental Coordination Disorder (DCD). DCD is characterized by a marked impairment in the development of motor coordination that is not the result of a specific medical condition, but interferes significantly with the child's academic achievement and daily functioning (American Psychiatric Association, 1994). Although it may be difficult to discern children with underlying DSI, from children with general motor coordination difficulties, Dahl Reeves and Cermak (2002) stated that dyspraxia is a more specific term, and likely a subtype of Development Coordination Disorder (DCD), where motor performance difficulties stem from a breakdown in the process of thinking about movement (i.e. how to plan, organize, and perform the motor-based activity) rather than simply the execution of the motor action itself.

Children with developmental dyspraxia demonstrate several observable behavioral symptoms. They may appear clumsy and poorly coordinated, demonstrate difficulty learning and sequencing new movements, as well as appear disorganized or lack initiative within their environments (Giuffrida, 2001; Hanft, Lane, & Miller, 2000; Missiuna & Polatajko, 1995). A study by Parham (1998) also suggested that praxis was strongly correlated with math achievement. In this study, 91 children; 43 of whom were identified as learning disabled were administered the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) and the Kaufman Assessment Battery for Children (K-ABC) (Kaufman & Kaufman, 1983), a measure of general cognitive ability and academic achievement. Results suggested that sensory integration measures, particularly clusters involving praxis were predictive of math achievement at 6 to 8 years of age. Four years later, when the participants were 10 to 12 years of age, performance on the SIPT was predictive of both math and reading and achievement.

Dysfunction in sensory discrimination is a problem interpreting the temporal and spatial characteristics of sensory stimuli so that the ability to perceive qualities of sensory stimuli is impaired (Lane et al., 2000). Accurate discrimination of sensory input is essential for the development of skilled movements and function (Spitzer & Smith Roley, 2001). Most sensory systems including taste, touch, smell, vision, and hearing have clear discriminatory functions, whereas the discriminatory capacity of the vestibular-proprioceptive system remains somewhat less clear. Although some higher-level cognitive deficits may also impact sensory discrimination functions, a range of behavioral and performance difficulties have been described and associated with dysfunction in sensory discrimination (Hanft et al., 2000).

Hanft et al. (2000) have summarized examples of sensory discrimination difficulties across all sensory systems. Individuals with poor tactile discrimination may have difficulty differentiating or manipulating objects without close visual monitoring and/or difficulty localizing touch on their body. An individual with poor auditory discrimination may have problems locating the source of sounds, or judging the distance and location of a sound. Poor visual discrimination may result in problems recognizing or categorizing colors, shapes, and textures; changing visual focus rapidly; scanning sequential images, or differentiating foreground from background images. Poor vestibular-proprioceptive discrimination may result in problems with dynamic balance, maintaining an upright posture, as well as gauging the correct amount of force to use with people or objects (such as when writing with a pencil or giving a hug). Although behaviors suggestive of poor sensory discrimination have been described, this subtype of DSI is not as well defined in the literature and less validated than the other subtypes.

Sensory modulation disorders are defined as problems in the capacity to regulate and organize the degree, intensity, and nature of response to sensory input in a graded and adaptive manner (Lane et al., 2000). Three types of patterns are common which include over responsivity, under responsivity, and fluctuating responses to sensory stimuli. Children who tend to be over responsive are thought to have a greater sensitivity to sensation in comparison to individuals with normal sensory modulation under the same sensory conditions. In contrast, children who are under responsive, theoretically, have a diminished or slow response to sensory stimuli in comparison to individuals with normal sensory modulation processes. Individuals with fluctuating responsivity have the tendency to rapidly shift between over and underresponsivity to sensation. They may display both hypo and hyper responsive behaviors and inconsistent responses to sensory input.

Poor modulation of sensory input has been associated with an array of maladaptive behaviors such as emotional reactivity and aggression, as well as disorganized, withdrawn, or avoidant behaviors (Hanft, Miller, & Lane, 2000; Wilbarger & Wilbarger, 1991, 2001). Children with over responsive tendencies may display a rapid, exaggerated response to stimuli or withdraw from stimuli that most individuals perceive as benign (Dunn, 1999). They may appear easily distracted by seemingly minimal sights and sounds, be fearful of sudden movement and/or loud noises, or react aggressively to unexpected touch. These hyper responsive tendencies have been historically described by Ayres (1979) in response to touch and movement and noted as tactile defensiveness and gravitational insecurity, respectively, as well as sensory defensiveness (Wilbarger & Wilbarger, 2001).

Children with under responsive tendencies have a slow response to sensory stimuli, and may appear both withdrawn and avoidant, or overactive and disorganized Dunn (1999). It is theorized that it takes a higher intensity or increased duration of the input to elicit a response (Dunn 1999). Children with under responsive tendencies may seek intense sensory experiences (e.g., high intensity movement activities, touch or mouth objects constantly), or demonstrate flattened responses to sensation (e.g. show less awareness of details, appear clumsy and bump into objects or other children) (Hanft et al., 2000).

Some of the theoretical assumptions and physiological correlates of sensory modulation disorders have recently been validated with preliminary research. McIntosh, Miller, Shyu, and Hagerman (1999) and Miller et al. (1999) used physiological indicators (electrodermal skin responses [EDR]) to measure responses to a series of sensory stimuli in groups of children with Fragile X syndrome and Sensory Modulation

Disorder. In both of these studies, the children were exposed to different sensations (e.g. touch movement, sound, etc) using a systematic sensory challenge protocol. Abnormal physiological differences as recorded by EDRs were noted in both groups of children in comparison to age and gender matched controls of children with typical development. The abnormal EDRs were also consistent with reported differences on behavioral measures of sensory processing as reported by the children's' caregivers on the Short Sensory Profile (Dunn, 1999). In summary, the results reflected greater sensitivities to irritating sensory stimuli and decreased abilities to cope in response to these sensations in children with Fragile X Syndrome and sensory modulation disorder.

Sensory Processing and Integration: Current Directions

The theoretical constructs related to sensory processing and integration continue to evolve. A brief description of one emerging model by Dunn (1997) provides us with information regarding the impact of sensory processing on daily life. Normal responses within this behavioral continuum are briefly described. In addition, recent research that documents sensory processing difficulties in children with disabilities is also highlighted.

Dunn (1997) has integrated concepts from SI theory, neuroscience, and behavioral science to describe the relationships between neurological thresholds and a continuum of behavioral responses related to sensory processing in daily life. From this perspective, the ability to modulate sensory input based on underlying neurological thresholds drives a continuum of adaptive behavior (Dunn, 1997). When the ability to process and modulate sensory input is efficient and accurate the individual can cope and respond appropriately to the multitude of sensory information from the environment and maintain functional performance. In contrast, when sensory modulation is poor, the individual cannot respond in accordance to the task or demands. This is due to disorganized or inaccurate information, which results in stressful, disorganized or maladaptive behavior.

Dunn's (1997) conceptualization of habituation and sensitization also contribute to our understanding of the impact of sensation on daily functioning and adaptive behavior. Habituation, according to Dunn, is defined as the organism's recognition that something familiar has occurred (Dunn, 1999). Habituation allows the CNS to filter unimportant or irrelevant stimuli and attend to pertinent information. Habituation is needed to cope with the multitude of stimuli that are constantly present in the environment. Sensitization is defined as the nervous system mechanism that enhances potentially important stimuli (Dunn, 1999). Sensitization allows the CNS to attend to novelty, which directs attention toward dangerous or unusual stimuli that elicit a protective response or drives exploration and learning. Such responses can also trigger the sympathetic nervous system, or a " flight or flight response." This results in a high level of arousal or alertness, which primes the CNS to take immediate action. Smelling smoke or hearing a fire alarm are examples of sensory input that may trigger these responses. A balance of habituation and sensitization, and the ability to effectively modulate sensory information are thought to be important for the development of adaptive behavior.

As with other areas of development, it is important to understand that there are a wide range of "normal" behavioral responses within this continuum and that differences in sensory processing and integration represent one way to interpret some maladaptive behaviors (Hanft et al., 2000). Responses between and within individuals vary greatly, in most cases contributing to individual differences in behavioral aspects such as arousal, adaptation to stress, motivational and adaptive behavior (Dahl-Reeves, 2001). For example, many children show variability in their responsivity and subsequent preferences for movement. Some children thrive on fast movement and seek high-energy activities on the playground, while, other children who prefer sedentary play, may dislike or experience discomfort on playground equipment, roller coasters, etc. Likewise, an individual may enjoy listening to the radio, however, when trying to read, or in the midst of a noisy household, the music may be irritating or distracting. Although the music is "distracting, " the individual is able to recognize and cope with this source of stimuli by removing it and continuing with necessary activity. These "preferences," therefore, do not interfere with day-to-day functioning and individuals with typical sensory processing and integrative abilities are able to adapt to changes in their environments or self direct their behavior to meet their sensory needs. It is when poor modulation and subsequent behavioral responses consistently interfere with the child's ability to cope with daily functioning that behaviors become maladaptive and problematic (Dunn, 1997).

Sensory processing differences, based on current conceptual models, have recently been documented in children with various disabilities (Baranak et al., 1997; Dunn, 1997). Dunn's (1999) development of the Sensory Profile, a standardized behavioral checklist with normative data, has been a significant contribution to this body of literature. Dunn used this tool to compare the sensory profiles of 1,037 children with disabilities to children without disabilities. She found that children with disabilities demonstrated a greater number and frequency of behaviors associated with sensory processing difficulties. In addition, a discriminative analysis that included different diagnostic groups of children with disabilities (e.g., ADHD, autism, fragile X) indicated that different disability groups demonstrated distinct patterns of performance, suggesting the potential for differential diagnosis and more refined intervention planning (Ermer & Dunn, 1997). For example, children with ADHD scored high only on distractibility indices when compared to children without disabilities. Children with autism had opposite patterns of performance from children without disabilities suggesting distinct sensory processing differences across several sensory domains of the Sensory Profile. In an additional study by Baranek et al. (1997) it was also estimated that up to 30% of individuals with developmental disabilities had problems with sensory processing and modulation.

Assessment of Sensory Processing and Integration

Sensory processing and integration is typically assessed through a combination of standardized tests, caregiver interviews, behavioral checklists, as well as formal and informal observations of the child's movement, play, and social interactions (Bundy, 2002; Parham & Mailloux, 2001; Windsor, Smith-Roley, & Sklut, 2001). Such tools and observations provide a range of data from which to hypothesize about the child's neurobiological processing of sensation and it's impact on behavior and performance. From a SI perspective, behavioral problems and performance difficulties are thus, reframed by analyzing motor performance and behavior, and thinking about sensory processing and integration (Ayres, 1979). It is essential to consider the use of multiple tools and strategies when assessing DSI.

Standardized tests provide a reliable and systematic method to assess development and behavior. The Sensory Integration and Praxis Test (SIPT) (Ayres, 1989) provide the most in-depth evaluation of sensory integrative functions primarily related to praxis (Bundy, 2002). The SIPT consists of 17 subtests that evaluate somatosensory processing, praxis, visuomotor function and motor free visual perception. While this test is considered a "gold standard" amongst sensory processing and integration assessment tools, it has a limited application to many individuals with identified disabilities (Windsor et al., 2001). For example, significant difficulties with attention, comprehension of instructions, and manipulation of test items are all factors that could interfere with the child's ability to complete this comprehensive and lengthy test battery (Windsor et al., 2001). While few other tools specifically identify dysfunction in sensory integration, several standardized assessments of motor and sensorimotor development include items or subtests from which inferences about the child's sensory processing and integration abilities can be drawn (Bundy, 2002; Parham & Mailloux, 2001). Examples of these tests include the Bruininks-Oseretsky Test of Motor Proficiency (Bruninks, 1978), Quick Neurological Screening Test (Mutti et al., 1998), and the Miller Assessment for Preschoolers (MAP) (Miller, 1988).

Formal and informal observations of a child's interaction with the physical and social environment are also key components of an evaluation of sensory processing and integration. Formal clinical observations of neurological soft signs and postural functions (e.g., integration of reflexes, postural responses to movement, and muscle tone) have historically been used to supplement standardized assessments and to contribute to understanding dysfunction in sensory integration (Ayres, 1979; Bundy, 2002). Limitations of these observations, however, include a lack of standardization and normative data and the notion that many of these observations address motor functions that may be strongly affected by conditions other than DIS, as well as normal neuromaturation (Parham & Mailloux, 2001). Informal observations of a child's movement, play and social interaction skills across different environments can also provide important insights about how the child responds to and organizes sensation, and how this affects their behavior, adaptation and skill performance. Such observations provide important contexts for interpreting and applying standardized test results, but are widely variable based on the individual child and his or her physical and social environments.

Sensory-motor histories, checklists and interviews have also been used to document sensory processing and integration functions (Dunn, 1999; Parham & Mailloux, 2001; Windsor et al., 2001). Such tools typically involve caregiver ratings of a child's behavioral responses to various types of sensation across different environments. Information from these tools provide a systematic format for caregivers to report their observations and perceptions of the child's behaviors which can further contribute to our understanding of how DIS may be impacting children in their daily lives and routines (Dunn, 1997). The Sensory Profile (Dunn, 1999) is one example of a recently standardized sensory history checklist that has been useful in documenting sensory processing differences, primarily related to sensory modulation, in children with various disabilities (Baranak et al., 1997; Dunn, 1997).

Sensory-Motor Development and Prenatal Alcohol Exposure

This section reviews the effects of prenatal alcohol exposure on children's sensory-motor development. Studies that have examined sensory processing and integration in children with alcohol-related conditions reflective of the theoretical framework just described will first be reviewed. Although few studies with alcohol-exposed children have examined sensory-motor development from a SI perspective, many researchers have investigated aspects of motor, neuromotor, and neuropsychological performance that include some measures of sensory perception and/or sensory-motor development. Such studies also inform us about sensory processing and integration and related abilities in this population.

Morse et al. (1995) provide us with one of the few studies to date that systematically examined sensory processing and integration in children with FAS and alcohol-related diagnoses. These authors used an 80-item sensory history questionnaire with 90 children with FAS/FAE and 90 controls ages 2 to 19 years of age. Scores on measures of sensory processing and related behaviors for children in the FAS/FAE group were 2 to 6 times higher than children without prenatal alcohol exposure. These results suggested that children with prenatal alcohol exposure differed from typically developing children in their responses to tactile, auditory, vestibular, and visual sensory information. Limitations of this study, however, included the lack of use of a standardized sensory-history questionnaire and the wide age range of the children included in the study.

Fulks and Harris (1996) reported decreased sensory processing abilities in a sample of 54 preschool aged children exposed to 2 or more drugs in utero, however, alcohol exposure was documented in only 39% of this clinical sample. These children were assessed with the Miller Assessment for Preschoolers (Miller, 1988), a standardized developmental screening test, as part of a developmental follow-up clinic protocol. Total scores on the MAP yielded no specific pattern of dysfunction according to normative data. However, scores on the subtests that assessed sensorimotor foundations (involving tactile, proprioceptive and vestibular tasks), coordination, and verbal abilities were skewed towards the low average range. The percentage of children (15%) that scored in the definite problem range (0 to 5th percentile) was also greatest for the Sensorimotor Foundation index. Although this study suggested developmental weaknesses in sensory-motor foundational skills among a clinical sample of children exposed to drugs in utero, generalization of these results to children with FAS and alcohol related diagnoses are limited due to a lack of systematic documentation of the alcohol exposure and a high percentage of children exposed primarily to other substances.

Neuropsychological studies that have examined tasks related to sensory-motor performance in children with prenatal alcohol exposure have yielded inconsistent results. In these studies, selected sensory motor tasks were often part of more comprehensive neuropsychological and neurobehavioral test batteries. Sensory-motor findings from these studies, although informative, address only limited components of sensory processing and integrative functions.

Mattson, et al. (1998) reported significant findings on specific neuropsychological tests of fine motor speed and precision (grooved pegboard test) and measures of visual motor integration in a sample of 25 children diagnosed with FAS and prenatal exposure to alcohol (PEA). Children with FAS and PEA performed more poorly than the control group of typically developing children on these measures, as well as on other neuropsychological and cognitive tests. In contrast, Janzen et al. (1993) found no differences in 3 1/2 to 5 year-old children with FAS/FAE on a neuropsychological test of fine motor speed and precision (grooved pegboard test), although they did report poorer performance on motor and perceptual components of the McCarthy Scales of Children's' Abilities in the same group. Barr and colleagues (1994) also reported no significant effects of alcohol exposure on sensory-motor measures that included tactual performance, grip strength and finger tapping in longitudinal sample of preschoolers exposed to moderate levels of alcohol. Finally, Korkman, Kirk, and Kemp (1998) compared 10 children with FAS (mean age 9.2 years; IQ > 80) with a control group of typically developing children on the NEPSY, a developmental neuropsychological assessment. No significant difference on the Sensorimotor core domain of the NEPSY was found despite significant differences in other domains, which included attention/executive functions, memory and learning, visuospatial processing, and language. The small sample size in this study may have contributed to limited findings in the sensory-motor domain, despite findings in other domains.

As mentioned previously, mild to severe motor deficits have been well documented in children with FAS or prenatal alcohol exposure (Harris et al., 1993; Barr, Streissguth et al., 1990; Mattson et al., 1996; Janzen et al., 1995). While most of these studies report general motor problems (e.g. clumsiness, poor fine motor coordination, and motor delays), few researchers have considered the relationship of such motor deficits to sensory processing and integrative functions, and broader functional performance.

Roebuck, Simmons, Richardson, Mattson, & Riley, (1998) however, have further explored the nature of balance deficits in children with prenatal alcohol exposure. These researchers compared 12 children with alcohol exposure with 12 matched controls on measures of postural and neuromuscular responses to movement perturbations. Such procedures were designed to determine whether balance deficits in children from a previous study were central or peripheral in nature (Roebuck et al.). The group of children with alcohol exposure demonstrated balance and postural responses, as measured by electromyographic activity of the lower extremities that were significantly different from the matched controls. The authors concluded that these balance deficits were at least partially related to central processing deficits involving the integration of somatosensory, visual and vestibular information, rather than peripheral deficits in these systems. Such findings may be suggestive of CNS difficulties related to sensory integration and processing dysfunction that may contribute to balance problems in children with prenatal alcohol exposure, however, more research is needed to confirm these findings.

Finally, there are several neurobehavioral concerns in young children with prenatal exposure reported in the literature that could be considered indicative of poor sensory processing and integration. In neonates, for example, prenatal alcohol exposure has been associated with lower levels of arousal (i.e. more frequently in a drowsy state versus alert or sleep state) and poor habituation to stimuli (Elyer & Behnke, 1999). This could suggest that neonates with prenatal alcohol exposure have poorly modulated responses to sensory stimuli (i.e., they are less responsive to stimuli or are more likely to "shut down" in response to over stimulation). Irritability, a weak suck, poor habituation, sleep problems, and failure to thrive have also been commonly reported in infants with prenatal alcohol exposure (Harris et al., 1993; Elyer & Behnke, 1999). These symptoms are also potential indicators of poor sensory processing and integration. Deficits in attention, impulsivity, emotional lability, and high activity levels have been consistently reported in early childhood, (Janzen et al., 1995) late childhood, adolescence, and adulthood, which are behaviors frequently described in children with DIS (Wilbarger & Wilbarger, 1991). All of these behaviors and symptoms, to some extent have been associated with DIS (Ayres, 1972; Dunn, 1997; Hanft et al., 2000; Kimball, 1999).

Why Examine Sensory Processing and Integration in Children with Prenatal Alcohol Exposure?

Cleary, sensory processing and integration problems are associated with a wide range of behavioral and developmental difficulties, many of which have been reported in children with FAS and alcohol-related conditions. Therefore, in consideration of both strengths and limitations of this theoretical framework, there are several reasons why sensory processing and integration deserves further study in young children with prenatal alcohol exposure. First, it provides a theoretical framework for examining neurobehavioral disorders related to subtle CNS dysfunction. Second, sensory processing and integration have not been widely examined in young children with prenatal alcohol exposure in spite of preliminary research evidence and anecdotal information that suggest difficulties in this area (Morse et al., 1996). Finally, sensory integration and processing problems are identifiable in young children, which have implications for early identification and early intervention and the potential to contribute to improved developmental outcomes.

A SI framework can be used to examine behaviors related to the CNS processing, organization and integration of sensory input. From a theoretical standpoint, the diffuse problems in CNS organization and subtle problems in information processing described in children with prenatal alcohol exposure have common presentations with those of children with DSI. A SI framework also considers dysfunctional behavior in terms of an underlying organic basis, as opposed to being a purely psychological or motivational problem. Thus, the ability to reframe behavior becomes a valuable component of this theoretical perspective.

In addition, the systematic assessment of sensory integration and related behaviors in young children with prenatal alcohol exposure is limited. Studies that have examined sensory-motor skills in this population have yielded inconsistent findings. Therefore, additional research is warranted. In addition, there remain questions about the construct of sensory processing and integration, and the nature and degree to which problems in this domain impact the daily function of children.

Finally, sensory processing and integration problems are identifiable in early childhood. The prevention of secondary disabilities through early identification and intervention has been reported as an important step in supporting children with prenatal alcohol exposure and their families. Streissguth (1997) states that an alcohol-related diagnosis by age 6 was related to reduced odds of secondary disabilities later in life and considered a "protective factor" in later development. She further points out that seven years was the mean age of the identification and treatment of behavior or mental health problems for individuals with FAS/FAE in her natural history study. While identification of sensory processing and integration and related problems may not directly impact diagnosis, early recognition may have important implications for the implementing services to prevent secondary disabilities. An understanding of a child's sensory profile also helps caregivers to modify the environment to promote the child's ability to respond and adapt to their surroundings.

Educational Relevance

Educators and related services personnel in the public school need to understand the impact of prenatal alcohol exposure on learning and development for several reasons. Current professional knowledge of FAS and alcohol-related conditions is limited (Wentz, 1997; Sloan, 2000). In addition, this group of children has been identified as a high-risk population in need of better interventions and improved educational outcomes (U.S. Dept of Education, 2000). Furthermore, educators are a primary point of contact for all children, and therefore in a key position to identify and intervene with children affected by prenatal alcohol exposure.

A1995 national survey of special education administrators reported that most states and school districts had limited means of identifying, tracking, and intervening with children with FAS (Wentz, 1997). Regular and general educators also had limited preservice and in-service training opportunities on FAS. Likewise, a survey of pediatric occupational therapy practitioners indicated limited general knowledge of FAS and consequently, limited guidance regarding assessment and intervention strategies (Sloan, 2000).

The U.S. Department of Education has also identified children exposed to alcohol as one group of children in need of academic interventions and improved school related outcomes (U.S. Dept of Education, 2000). Prevention and early identification of learning and behavioral difficulties in school-aged children have been highlighted as important goals on the national agenda for improving outcomes for children with emotional and behavior disorders in the schools and other community settings (Osher & Hanley, 1996). Children with alcohol-related diagnoses exhibit a continuum of learning and behavioral difficulties that are often difficult to recognize or are misunderstood. While many children affected by prenatal alcohol exposure qualify for special education and related services based on developmental delays, cognitive, behavioral, and/or learning problems, many children with alcohol related conditions do not. Therefore, without adequate support, children with prenatal alcohol exposure are at high risk for school problems, academic failure, and school drop out (Streissguth, et. al., 1996).

Well-informed educators are in a key position to identify children and provide early intervention and supportive educational services. Education is an entitlement available to all children; therefore, children with alcohol-related diagnoses have access to educational services, whereas medical, mental health, or other community-based services may be less available or more costly. Since learning and behavioral difficulties are often cited as a primary reason for seeking intervention, it follows that preschools, "child find" and special education programs have an important role as a primary point of entry into a system of care and network of support for children with FAS and alcohol-related diagnoses and their families.

Finally, supportive programs may also contribute to the prevention of secondary disabilities by helping children develop their strengths and constructing supportive and developmentally appropriate environments in order to help acquire maximum levels of vocational, interpersonal, and adaptive skills. Knowledge of areas of strength and weakness, as well as the potential for functional and adaptive problems, can further alert educators of problem behaviors that may help to proactively support children even when they are not 'eligible" for services.

Occupational Therapy as a Related Service

Occupational therapy is a mandated special education related service in the public schools and early intervention programs under the Individuals with Disabilities Education Act (1997). The primary goal of occupational therapy in the schools is to provide support for children's academic performance in the presence of physical or psychosocial disabilities that impact school-related functional abilities. The primary role of the occupational therapist (OT) in special education is to "facilitate educational outcomes in collaboration with other professionals who are providing services for the child and family." (AOTA, 1987). Occupational therapists support children through direct intervention, consultation with teachers and parents, as well as through the early identification and monitoring of children with developmental delays or disability.

Occupational therapists often apply a sensory integration framework to understand the relationship between CNS dysfunction, behavior and learning difficulties in the schools, as deficits in sensory processing and integration can have a significant impact on students' school performance (Mailloux, 1997; Sarracino, 1997). This framework is essentially used to evaluate how DIS, or subtle differences in CNS function, impact learning and behavior. For example, students who cannot cope with ongoing changes in sensory stimuli in their classroom environment, or cannot write or sit still in their seat due to motor incoordination, have inefficient foundations from which to concentrate or focus on learning and academics and social interactions.

A recent survey of 131 pediatric occupational therapists suggested that a sensory integration framework was used by 81 % of respondents when working with children with FAS and was a primary area of intervention focus (Sloan, 2000). It also important to note that, children of preschool and elementary school age constituted the highest percentage of children with FAS served by survey respondents. Thus, specific knowledge of sensory processing and integration problems in relation to the development of young children with FAS and alcohol-related diagnoses has important implications for OT screening,

assessment, and intervention within the educational system. A more clear understanding of the relationship between sensory processing and integration and adaptive behavior can contribute to the evaluation and intervention efforts of occupational therapists in the educational system and greater community.

Research Questions

Sensory processing and integration problems in children with FAS and alcohol-related diagnoses warrant further examination. In this population, systematic investigation of this area of neurobehavioral functioning is currently very limited. Indeed, a standardized and comprehensive survey of sensory-motor functions from an SI perspective has not been completed in young children affected by prenatal alcohol exposure. Examining the development of young children with FAS and alcohol-related diagnoses has important implications for early identification and subsequent prevention of secondary learning and behavioral problems. Furthermore, exploration of the relationships of sensory processing and integration problems with adaptive skills, behavior, and early school performance to clarify the potential functional manifestations of DIS in this population has not been done. Examining the relationship between sensory processing and integration and functional behavioral measures has also been considered a crucial component of research necessary to the ongoing refinement of SI theory (Dunn, 1997). These factors provide the rationale for the following research questions:

1. What are the characteristics of sensory processing and integration dysfunction in young children with alcohol-related diagnoses?

2. How does the performance of young children with alcohol-related diagnoses compare with a group of typically developing peers on measures of sensory processing and integration?

3. How does the performance of young children with alcohol-related diagnoses compare with a group of typically developing peers on measures of adaptive behavior and school performance?

4. What is the relationship between measures of sensory processing and integration, adaptive behavior, and school performance among young children with alcohol-related diagnoses?

5. What measures of sensory processing and integration, adaptive behavior and early school performance discriminate between young children with alcohol-related diagnoses and children with typical development?

Methods

Participants

Twenty-five children with known alcohol-related diagnoses and 26 children with typical development ages 5 years 0 months through 8 years 6 months were compared on measures of: 1) sensory processing, 2) sensory-motor performance, 3) adaptive behavior, and 4) school performance. Participants with alcohol-related diagnoses were recruited through the University of Washington Fetal Alcohol Syndrome Diagnostic and Prevention Network (UW FAS-DPN) registry. This registry contains over 1,500 children and adults who have been systematically diagnosed with FAS or alcohol-related conditions at the University of Washington. Children with typical development matched for age, gender, and racial/ethnic background were recruited from local urban and suburban schools for the comparison group. Children in the comparison group were all enrolled in a regular education program (i.e., children in special education services were not recruited to participate in the study). Children in the comparison group were not formally screened for prenatal alcohol exposure. It was assumed that the risk of prenatal alcohol exposure at teratogenic levels was minimal in this group of children and that alcohol exposure in this sample would reflect that of the general population.

In order to minimize the impact of an unstable home or family environment on behavior and test performance, as well as the influence of severe physical disabilities or mental retardation on test performance, children with alcohol-related diagnoses were excluded from the study for the following reasons:

1) If the child was in the current home/foster care placement for less than 1 year.

2) If the child showed evidence of severe physical, cognitive or neurological disability (e.g. cerebral palsy, spina bifida, severe mental retardation).
3) If a parent reported or the child's records included IQ scores or related cognitive measures with a standard score below 60 or descriptive evidence of mental retardation.

Alcohol-related diagnoses were defined by the diagnostic criteria established by Astley and Clarren (1999). This diagnostic system uses a systematic 4-point Likert-type scale to describe the continuum of effects in each of four diagnostic areas (brain, growth, face, alcohol exposure). (See Appendix A). Children with evidence of neurobehavioral difficulties (brain codes 2, 3 or 4; See Appendix B) and confirmed prenatal alcohol exposure (codes 3 or 4; See Appendix C) were recruited for the study. Sixty percent of the children had confirmed alcohol exposure at high levels, whereas the other 40% had evidence that alcohol was used during the pregnancy, however specific amounts were not available. Eight (32 %) of the 25 children in this group had evidence of structural brain differences. Only three (12%) of the children in the group with alcohol-related diagnoses met the diagnostic criteria for Fetal Alcohol Syndrome. Each alcohol-related diagnosis was made by a physician in collaboration with a multidisciplinary team. Data informing the diagnostic process was acquired through medical history and records, an extensive caregiver history, physical examination, as well as psychometric testing.

Participant Recruitment

Parent/guardians of children from the FAS DPN registry who met eligibility criteria were sent a letter of invitation with a stamped postcard response (See Appendix D for the letter of invitation and postcard response). Interested parent/guardians were asked to contact the investigator by telephone, or return the stamped postcard response, which gave the investigator permission to contact them by phone. The parent/guardian was then provided with more details of the study by telephone (See Appendix E for the telephone script). Consent forms were sent to the parents/guardians who agreed to participate and each child was scheduled for a test session at home or at the University of Washington, based on what was most convenient for the parent (See Appendix F for the consent letter). Non-respondents were sent a one-time follow-up letter (See Appendix G). Letters were sent to the families of 73 children who met the study eligibility criteria. The families of 25 children (34%) agreed to participate.

Children with typical development in the comparison group were recruited through local urban/suburban schools and community programs in cooperation with the school principal, teachers, and/or program directors. Initially, 200 recruitment letters were sent to the parents/guardians of children in grades kindergarten through two, at one University of Washington College of Education partner school, based on matching criteria (i.e., child's age, gender). Only 12 (6%) families at the school agreed to participate. Due to this low response rate additional recruitment efforts were initiated including contact with a university kindergarten program, two community after-school programs and word of mouth. Enrollment response rates for the letters of invitation sent through these programs also remained low, at 6% to 8%.

Each family received a letter of invitation to participate with a stamped postcard response (See Appendix H for the letter of invitation and postcard response). Interested parent/guardians were asked to contact the investigator by phone, or return the postcard response, which gave the investigator permission to contact them by phone. The parents/guardians were provided with more details of the study by telephone (See Appendix E for the telephone script). Parents/guardians who agreed to participate were sent a letter of consent, and the child was scheduled for a test session at home, school, or at the University of Washington (See Appendix I for the consent letter).

After informed consent was obtained, participants were scheduled for a 2-hour testing session at the child's home, school, or at the University of Washington. The child's primary caregiver completed two behavioral checklists: 1) Short Sensory Profile (Dunn, 1997), and 2) Scales of Independent Behavior-Revised (checklist version) (Bruininks, Woodcock, Weatherman, & Hill, 1996), and a brief demographic questionnaire (See Appendix J for the questionnaire). In addition, each child's teacher completed the teacher version of the Social Skills Rating System (SSRS) (Gresham & Elliot 1990). The SSRS was mailed to each teacher, with a cover letter, a copy of the signed informed consent letter and return postage paid envelope. The investigator provided directions for completing each checklist in the letter and was available by phone if there were questions (See Appendix K for the teacher cover letter).

After providing verbal assent, (See Appendix L for assent script) each child was given a battery of standardized developmental tests administered in the same sequence. If the child became uncooperative, frustrated or fatigued, the examiners encouraged the child to take breaks as needed. If the child was unable to complete the entire test battery a second test session was scheduled to complete the testing. Only two (8%) children in the alcohol-exposed group required an additional test session. None of the children in the comparison group required an additional test session.

One pediatric occupational therapist with two years of clinical experience and one physical therapist with 10 years of clinical experience completed the testing. The primary investigator scheduled the test sessions. Each examiner tested an approximately equal number of children with alcohol-related diagnoses and typical development, and was unaware of the group status of the children.

Procedures

Procedural Training and Test Administration

Examiners were trained in the test administration by the investigator, a pediatric occupational therapist with 10 years of clinical experience. Both examiners reviewed the test manuals and observed one test administration by the primary investigator. Each examiner also practiced test administration on two children with typical development and observed two additional children to establish inter-rater agreement. Inter-rater agreement between examiners on all performance-based measures reached or exceeded .85 prior to testing the study participants. Inter-rater agreement checks with the primary investigator were then made randomly for each examiner for a total of 6 checks (3 children with alcohol exposure, 3 children without alcohol exposure). Inter-rater agreement did not fall below .85 on any of the measures during the study. The mean inter-rater agreement percentages were reported on the following measures after training sessions and during follow-up, respectively: Bruninks-Osertesky Test of Motor Proficiency, point-by-point agreement (91% and 93%); Quick Neurological Screening Test-II, item-by-item agreement (90% and 93%); categorical agreement (89% and 87%). Point-by-point and categorical agreement is reported for the QNST-II due to the qualitative nature of the items in this tool. Inter-rater agreement was reported in this study instead of reliability because of the clinical significance of consistent observations and ratings among examiners.

Test protocols were administered and scored by the examiners and followed the standardized test procedures specified in each test manual. All scoring was reviewed by the primary investigator for accuracy and then entered into a database. Since results may have indicated previously unknown learning or developmental problems, particularly in the group of typically developing children, tests results from any child who scored in an area of concern (as defined by the scoring criteria on each individual tests) were shared with the parent/guardian upon request. Thirty-four (66%) of the parents/guardians requested the test results. Based on the results of the test and professional judgment, an appropriate referral to community resources, such as school districts or other community programs was recommended to the parents for follow-up as needed.

All of the participants' caregivers and teachers were fully informed about the risks and benefits of the study. All test data were kept confidential and stored in a locked file drawer in the investigator's office. Test protocols were coded to keep the identity of the participants confidential. Only the investigator maintained links to these codes, which were also stored in a locked file drawer. All procedures met research standards set and approved by the University of Washington Human Subjects Review Board.

Parents/guardians were reimbursed for any parking expenses at the University of Washington. All participants received a small educational book for completing the study.

Instrumentation

The Short Sensory Profile (SSP)

The SSP (Dunn, 1999) measures a caregiver's report of behaviors related to sensory processing and integration abilities. The SSP is a standardized questionnaire of sensory processing abilities for children ages 3 to 10 years. Currently, this is the only standardized caregiver report of this nature that is published and available to occupational therapy clinicians. The SSP takes approximately 15 minutes to complete.

The SSP consists of seven sections that measure the following domains of sensory processing: 1) Tactile Sensitivity, 2) Taste/Smell Sensitivity, 3) Movement Sensitivity, 4) Underresponsive /Seeks Sensation, 5) Auditory Filtering, 5) Low Energy/Weak, and 7) Visual/Auditory Sensitivity. The SSP contains 38 of 125 items from the Sensory Profile (SP) (Dunn, 1999). These were considered the strongest indicators of sensory processing difficulties and represented key sections and factors from the long form. The content validity of the original 125 items of the long form of the Sensory Profile was determined by literature review, expert review and categorical analysis. The SSP was then developed based on three phases of item reduction analysis and principal components factor analysis using data from the original standardization sample of 1,037 children without disabilities in comparison with a sample of 117 children with disabilities. The SSP essentially addresses some of the described limitations of the long form by eliminating fine motor and social-emotional items, which were considered products or outcomes of sensory processing, and reducing the test to those items with the highest ability to discriminate between children with and without disabilities (Johnson-Ecker & Parham, 2000; McIntosh, Miller, Shyu, & Dunn, 1999).

The internal validity of the SSP was determined by examining the inter-correlations of the SSP total score and section scores. Correlations between the SSP total score and the seven test sections were in the moderate range (r = .48 to .80). The weakest relationships with the total score were noted with the Movement Sensitivity (r =. 48) and Taste/Smell Sensitivity (r = .54) sections. Low to moderate inter-correlations were also noted between each section of the SSP (r = .25 to .76). For example, the correlation between the Movement Sensitivity section and Underresponsive/Seeks Sensation section was .25, while the correlation between the Visual/Auditory Sensitivity section and the Auditory Filtering section was .76. Both of these correlations reflect relationships in the expected theoretical direction (i.e., movement sensitivity and underresponsivity represent opposite ends of the continuum of responses to sensory information, whereas items on the visual and auditory sensitivity subtest and auditory filtering subtest reflect more similar behaviors, particularly related to how the child processes sounds). These inter-correlations suggest that the sections of the SSP measure unique aspects of sensory processing and support the factor structure developed.

Evidence of construct validity was documented by a study that compared children with sensory modulation disorder with age- and gender-matched children with typical development (McIntosh et al, 1999). Both groups of children received electrodermal skin response (EDR) testing to gauge their physiological responses to a series of imposed sensory stimuli. As hypothesized, children with abnormal EDR received significantly lower scores on the SSP. Thus, behavioral measures of sensory processing were consistent with physiological measures in children with and without sensory modulation disorder. In another study to determine the clinical utility of the SSP, 19 children who were clinically identified with sensory modulation disorder were compared with 19 age and gender matched controls on the SSP. The sensory modulation sample had lower mean scores on all subsections than the sample of children with typical development, which suggests that the SSP was able to discriminate between these two groups of children.

One limitation of the SSP lies in its limited reliability data reported. Internal reliability coefficients of the test and total test section were reported to range from .70 to .90, as calculated by Cronbach's alphas, thus items in each test section measure relatively separate constructs (Dunn, 1999). No additional inter-rater or test-retest reliability data are reported. Although standard errors of measurement and suggestions for calculating confidence intervals for retest reliability are presented for the long form, this information cannot be generalized to the SSP due to the differences in test structure.

The SSP is completed by caregivers who rate a list of behaviors on a 5-point Likert scale, which indicates the frequency of behaviors (i.e., always, frequently, occasionally, rarely, and never). Scoring is completed by assigning a point score based on the Likert Scale for each item and then summing the items to attain a total score for each section. The total test score is then based on the sum of the section scores. Lower scores indicate that problem behaviors occurred more frequently, thus less desirable performance. Classification categories for each section and the total test are then determined by the raw numeric score and based on a cut score from the standardization sample of 1,037 children without disabilities. Descriptions of the classification categories are as follows:

a) **Typical Performance** indicates scores were at or above 1.0 *SD* below the mean, and suggest no concerns.

b) **Probable Difference** indicates scores were between 1.0 and 2.0 *SD* below the mean, and suggest concerns that should be monitored or further assessed.

c) **Definite Difference** indicates scores were less than 2.0 *SD* below the mean, and suggest sensory processing difficulties that should be further assessed and treated.

Developmental Neuropsychological Examination: (NEPSY)

The NEPSY (Korkman et al., 1998) is a comprehensive test designed to assess neuropsychological development in children ages 3 through 12 years. The NEPSY consists of subtests categorized into five domains. These subtests can be administered in various combinations based on the needs of the examiner and child. The selected NEPSY core domains and test items reflect sensory-motor and motor planning skills typically assessed as part of a sensory processing and integration evaluation. While the NEPSY is not typically used by occupational therapists in clinical practice, many NEPSY items are representative of those used in other tools such as the Miller Assessment for Preschoolers (MAP) (Miller, 1988) and the SIPT (Ayres, 1989), measures more commonly used by occupational therapists. The strong technical characteristics of the NEPSY, the flexibility of the administration of individual and core domain items, the brevity of the NEPSY relative to the SIPT, and the wide age range of the test were additional reasons this tool was selected. Selected subtests take approximately 30 to 45 minutes to complete.

Subtests from the Sensorimotor and Visuospatial Processing core domains were used for this study. The sensory-motor tasks assessed by the NEPSY include the ability to process basic tactile information, imitate hand positions, produce repetitive and sequential finger and hand movements, and use a pencil with speed and precision. The tasks assessed by the Visuospatial Processing domain involve fine motor and visual-motor such as the ability to judge line orientation and copy two-dimensional figures. The expanded core domain items, which included reconstruction of a three-dimensional design from a block or picture, as well as locating a schematic target on a map were originally planned to be administered, but excluded in this study because of time limitations.

One subtest was administered from Attention/Executive Functions domain. This domain assesses abilities that include inhibition, monitoring and self–regulation, vigilance, selective and sustained attention, nonverbal problem solving and the capacity to establish, maintain and change a response set. The Visual Attention subtest was included because it reflects constructs related to the selective attention/inhibition of visual stimuli.

There is extensive psychometric information reported in the test manual on the reliability and validity of NEPSY (Korkman et al., 1998). In the process of test development, the NEPSY items were reviewed twice for content and bias by panels of experts to establish content validity. The patterns of correlations between the subtests in each of the domains provide evidence of sound test structure. Correlations between subtests in each domain (*r* = .65 to .77) were generally higher than correlations between core domain scores (*r* = .18 to .46). Details of these correlations are presented in several tables within the test manual.

Several studies by the test authors were also completed to determine the convergent and discriminant validity of the NEPSY (Korkman et al., 1998). The NEPSY's correlation with other neuropsychological measures was reported as moderate to high. Correlations between measures of general cognitive ability (*r* = .27 to .62) and the NEPSY subtests and domains were low to moderate; and correlations with measures of academic achievement were poor to moderate (*r* = .00 to .50) Domains related to language and attention/executive functions had stronger relationships with intelligence. The domains measuring language, memory and learning, and visuospatial processing were most related to academic achievement, whereas the sensorimotor and attention/executive functions were relatively unrelated to academic achievement.

Average test-retest reliability for 5 to 12 year-old children on the NEPSY was reported as adequate for the Sensorimotor domain (*r* =. 79), the Visuospatial Processing domain (*r* =. 83), and the Attention/Executive Function domain (*r* = .82) (Korkman et al., 1998). Interrater reliability using stability coefficients was also reported in the test manual. The average stability coefficients for the Sensorimotor and Attention/Executive Functions subtests were *r* = .67, and *r* = .70 for the Visuospatial Processing subtests, which are considered borderline to adequate.

The NEPSY scoring criteria and procedures are outlined in the test manual. Raw scores are derived from the child's performance on each of the test item, based on criteria described in the test manual. Raw scores for each of the subtests and the domains are converted to standard scores based on normative data in the test manual.

Quick Neurological Screening Test-II (QNST-II)

The QNST-II (Mutti et al., 1998) is a screening tool that measures neurological soft signs in children 5 years of age through adulthood. It consists of 15 items adapted from pediatric neurologic and neuropsychological examinations that sample fine and gross motor coordination, balance and vestibular function, visual and auditory perceptual skills, motor planning and sequencing, and spatial organization. Items on the QNST-II are presumed to be indicators of neurological maturation or integrity. Deficient performance on several of these measures may be suggestive of an underlying organic or neurological basis for learning or behavioral problems. The QNST-II takes approximately 20 minutes to complete.

This tool was selected because several QNST-II test items are often included as part of a thorough sensory-motor assessment by pediatric occupational therapists. These items, often referred to as clinical observations, were recommended by Ayres as a supplement to standardized tests of sensory integration and praxis and other motor abilities (Bundy, 2002; Parham & Mailloux, 2001). Historically, these neuromotor tasks have not been standardized, and results have been based on subjective examination. The QNST-II, however, provides a systematic means to examine these abilities as well as to compare performance to peers.

Evidence to support construct, concurrent and predictive validity of the QNST-II are presented in the test manual (Mutti, et al., 1998). This evidence is largely based on studies with the first version of the QNST (i.e. there are no item revisions or new standardized information on the QNST-II, only minor administration methods and scoring criteria were changed). A principal components factor analysis based on the performance of 122 children with learning disabilities provided evidence that the QNST measures the constructs of motor coordination and sensory and perceptual processes. However, it should also be noted that in two studies, soft neurologic signs as measured by the QNST were more prevalent in younger children (Ardilla & Roselli, 1996; Finlayson & Obrrzut, 1993). Ardilla & Roselli further noted that frequency of soft signs decreased with normal maturation. This indicates a potential limitation in using test with younger children, but supports the notion that the QNST-II provides relevant information about neuromaturation. Comparing the performance of the population of interest with a control group of age-matched children with typical development is one way to address this limitation with younger children.

Concurrent validity with measures of academic achievement, developmental screening tests, auditory perception, and medical/neurological exams has been reported. A correlation of $r = .51$ was found between the QNST and Brain Injury Factors on the Bender Gestalt for Children in 30 kindergarteners (Landon, 1978). Moderate negative correlations (r = -. 48 to -. 74) were noted between QNST scores and the Wide Range Achievement Test (WRAT-R). In a group of 20 high school freshmen, QNST scores were significantly correlated with other indices of scholastic ability (e.g. grade point average, IQ and teacher evaluation), although these correlations were weaker (r = -.25 to -.35) (Stephan, 1978). Thus, there is evidence that as QNST scores and evidence of neurological dysfunction increase, achievement and other school related performance scores decrease. In addition, some evidence of predictive validity is also reported in the test manual. In a group of 198 kindergarten children low QNST scores (within the normal classification category) were found to predict average or better reading ability scores at the end of first grade (Spalding, 1975).

Test-retest and inter-rater reliability data are presented in the manual (Mutti, et al., 1998). Test-retest reliability of the QNST-II was reported as .81, which is considered adequate. Interrater reliability reported as .69 to .71, which is low to borderline, but still significant. This is a potential limitation of the test. Interrater reliability checks, as specified in the research methods section, addressed this limitation.

The QNST-II is scored by rating each of the 15 test items based on behavioral criteria specified in the test manual. The 15 item subtest scores are then summed to obtain a total score. Each test item and the total score then yield a weighted score and classification category denoted as "normal," "moderate discrepancy," or "severe discrepancy." Children with a normal classification (0-25) are considered unlikely to have specific learning or related academic difficulties. An individual with a moderate discrepancy classification (26-50) may have one or more symptoms of a developmental or neurological etiology that may interfere with learning. An individual with a severe discrepancy classification score (above 50) likely demonstrates several developmental or neurological symptoms that may affect their learning abilities.

Bruninks Oseretsky Test of Motor Proficiency- Short Form (BOTMP)

The BOTMP is a tool commonly used by pediatric occupational therapists to assess the motor development of children (Bruninks, 1978). This tool provides a brief survey of general motor proficiency for children ages 4 through 14 years. Observations of motor skills can provide information relative to sensory integrative processes and outcomes. While the long form provides detailed information related to specific components of motor development (e.g. upper limb coordination, strength, etc.) such components are not of primary interest in this study and the administration time is considerably longer. Thus, the short form was selected to provide a general indicator of motor performance among study participants. The short form takes approximately 30 minutes to complete.

The short form items were drawn from the eight subtests in the long form, based on data obtained in the original standardization sample (Bruninks, 1978). The short form shows a high inter-correlation with gross motor, fine motor, and battery composite scores of the long form ($r = .78$, .76, and .91, respectively). Test-retest reliability of the short form was reported at .86, and the standard error of measurement (SEM) was reported as 4.6 (Bruninks, 1978).

Expert reviewers determined construct validity of the BOTMP based on analysis of the categories of motor behavior and development. Internal consistency data is also presented for the correlations between items within each subtest. Median correlation coefficients ranged from .65 to .87 and correlations with subtests items and the total ranged from .56 to .86. Evidence of discriminant validity is also described for both the long and short forms. Using *t*-tests for independent means, comparisons with groups of children with learning disabilities and mental retardation suggest that both the long and short forms of the BOTMP successfully discriminate between children who are typically developing and children with disabilities, in a manner consistent with similar comparative studies of motor performance.

The BOTMP short form is administered and scored based on standardized procedures in the test manual. Scores for each item are rated based on their respective performance criteria. Scores from each item are added and yield a final raw score, which is then converted to standard scores, percentiles and stanines based on normative data. Standard scores on the BOTMP are based on a mean of 50 with a standard deviation of 10.

<u>Scales of Independent Behavior-Revised (SIB-R)</u>

The SIB-R is a comprehensive measure of adaptive behavior and problem behavior for ages birth through adulthood (Bruninks et al., 1996). It is primarily designed to measure problem behaviors and adaptive functioning in home, school, employment, and community settings. This tool was selected because it provides functional measures of both adaptive skills and problem behaviors. Such measures can provide information on how sensory processing and integration problems affect daily function. In addition, the SIB-R can be administered in an interview or checklist format. The checklist administration procedure was used for this study. Administration time is generally less than one hour.

The SIB-R full scale is comprised of 14 subscales organized into 4 adaptive behavior clusters: 1) motor, 2) social interaction and communication, 3) personal living, and 4) community living. Each item is scored on a 4-point rating scale from 0 to 3. "0" indicates the child cannot do the task, even if asked. A "3" indicates that the child almost always does the task independently, and does it very well. The SIB-R presents a comprehensive set of results that yield a standard score, relative mastery index (RMI), and classification of age level tasks.

The SIB-R also contains a problem behavior scale, which contains a summary of eight problem behavior areas organized into three broad maladaptive behavior indices (Internalized, Asocial and Externalized). The frequency and severity of problem behaviors are rated, which then yield a sum that corresponds to one of five profile categories: 1) normal, 2) marginally serious, 3) moderately serious, 4) serious, and 5) very serious. Standard scores from the subscales and broad independence scale, and categorical results from the maladaptive behavior index profile will be used for the statistical analysis. .

The SIB-R is described as a technically sound measure of adaptive and problem behaviors (Bruininks et al., 1996). Strong psychometric qualities and extensive documentation of reliability and validity for the total test, subtests and problem behaviors domain are presented in the test manual (Bruininks et al., 1996). Test-retest reliability coefficients for the four cluster scores (motor, personal living, communication and social), broad independence score, and support score were all reported above .95. Coefficients for each of the subscales ranged from .83 to .97. Coefficients for the

Maladaptive Behavior Indexes were reported as .80 to .83. Interrater reliabilities were reported for parents of the same child as well as between teachers and teacher aides. Correlations for the four cluster scores, broad independence score, and support score were high between parents (r = .88 to .95) and teachers (r = .88 to .97). Correlations were somewhat lower between the subscales (r = .58 to 94) for parents and (r = .71 to.96) for teachers and the Maladaptive Behavior Indices (r = .78 to.86) and (r = .57 to .87) for parents and teachers respectively. The reliability coefficients of the Maladaptive Behavior Indices suggest this portion of the test is less stable and should be considered in the test interpretation.

Evidence of the test's validity includes information about the content of subtests and clusters, the correlations of certain clusters with tests and criteria traditionally used in the field, and the relationships between the test subscales and clusters. Over 22 studies have been completed to test the discriminant validity of this tool, which are summarized in the test manual (Bruininks et al., 1996). These multiple discriminant analyses provide strong evidence of test validity for diagnostic and classification purposes for a wide range of individuals with disabilities and adaptive behavior problems.

<u>The Social Skills Rating System (SSRS)</u>

The SSRS (Gresham & Elliot, 1990) provides a multi-rater assessment of student social behaviors from the perspective of the parent, student, and teacher. Three domains of social development are rated, social skills, problem behaviors, and academic competence. The SSRS is widely used among educators to measure general performance in the above areas and is considered a psychometrically sound tool. The SSRS-Teacher Form takes approximately 10 to 15 minutes to complete.

From a theoretical perspective, deficits in sensory processing and integration are likely to have a negative impact on general social and academic competence. Therefore, a broad measure of school performance skills was important to include in this study. The SSRS Teacher Report form for grades K-6 provides important information about school behavior and academic performance in the context of the school environment and in relation to classroom peers.

The test authors report evidence for content, criterion and construct validity of the SSRS (Gresham & Elliot, 1990) Content validity was established by using expert professional judgment and a survey of the literature. Criterion-related validity for the teacher report form was supported in three different studies by correlating the SSRS with performance on existing measures of behavior with teacher rating scales. Moderate to high correlations (r = .70 to .81) in the expected theoretical directions were noted for each of the SSRS scales with other behavioral measures that included the Child Behavior Checklist (Achenbach & Edelbrock, 1986), the Social Behavior Assessment (Stephens, 1981), and the Harter Teacher Rating Scale (Harter, 1985). The test manual summarizes multiple studies that provide strong evidence for the construct validity of the SSRS. These studies included the analysis of developmental changes, sex differences, measures of internal consistency, convergent and discriminative validity, factor analyses, and comparisons of contrasted groups (Gresham & Elliot, 1990).

Detailed information on the SSRS reliability and validity is reported in the test manual (Gresham & Elliot, 1990). The following internal consistency coefficients for each of the subscales on the teacher forms were reported: Social Skills (*r* = .94), Problem Behaviors, (*r* =. 88) and Academic Competence (*r* =. 95). Using the criteria of .80 and above, acceptable test-retest reliability for each of the subscales was estimated at .85, .84 and .93, respectively. Inter-rater reliability was not directly assessed, as a major assumption of the SSRS is that different raters are expected to contribute unique views on the child, and the rating forms are not identical. However, standard errors of measurement are reported for all scales using coefficient alpha internal consistency reliability estimates. In addition, convergent validity, defined as the relationship between raters of the same child (i.e. parent, teacher), was reported. Checks at each of the levels of the test resulted in coefficients ranging from .03 to .43, suggesting mild positive correlations.

The SSRS-Teacher form is completed by rating the frequency of behaviors in each section on a scale of 0-2 (0 = never and 2 = very often). Total raw scores are then determined by adding frequency scores for each subscale, which are then converted to the standard scores based on normative data. Each of the subscales yields a standard score with a mean of 100 and a standard deviation of 15. The Social Skills scale includes measures of cooperation, assertion and self-control. The Problem Behavior scale assesses externalizing and internalizing behaviors and hyperactivity. Each of these scales also yields a categorical behavioral level indicated by “fewer”, “average” or “more,” as determined by the raw score for each subtest scale.

Wide Range Achievement Test –3 (WRAT-3)

The WRAT-3 (Wilkinson, 1993) is a standardized test designed to measure the codes that are needed to learn the basic skills of reading, spelling, and arithmetic. The WRAT–3 is being included as a general measure of academic skills to provide descriptive information on study participants, and to explore the relationship between sensory processing and integration and academic achievement, since there is some evidence that deficits in sensory processing and integration are related to poorer academic achievement (Parham, 1998; Ayres, 1972). The WRAT-3 takes approximately 15 to 30 minutes to administer.

The WRAT-3 has 3 subtests: 1) Reading: which involves the recognition and naming of letters, and pronunciation of words out of context; 2) Spelling: which involves writing one's name, letters and words to dictation, and 3) Arithmetic: which involves counting, reading number symbols, solving oral problems and performing written computations. Each of the subtests are administered and scored using the standardized procedures outlined in the test manual. Raw scores are converted to standard scores based on a scale with a mean of 100 and a standard deviation of 15. Grade scores and percentile ranks can also be determined.

The test manual provides evidence that the test meets sound psychometric standards (Wilkinson, 1993). Strong evidence for the content validity of the WRAT-3 is provided by the Raasch statistic of item separation. Each set of test items of the WRAT-3 received an item separation score of 1.00, which is the highest score possible. This suggests that the test items, as well as the spread of the items are well defined and represent each of their respective domains well. Construct validity is supported by median subtest inter-correlations of .87 for the Reading-Spelling subtests, .66 for the Reading-Arithmetic subtests, and .70 for the Spelling-Arithmetic subtests. These correlations reflect a moderate to high positive relationship that supports the notion that the variables are related measures of academic abilities. Moderate positive correlations of the WRAT-3 with measures of verbal and performance IQ were also reported. In general, the reading, spelling, and arithmetic scores correlated more highly with verbal than with performance IQ scores. Such findings provide support for the hypothesis that the skills measured by the WRAT-3 are associated with general cognitive ability. Moderate correlations were reported between the WRAT-3 combined form and other measures of academic achievement which ranged from .41 to .80.

Several measures of test reliability were reported by Wilkinson (1993). Coefficient alphas used to measure the WRAT-3's internal consistency reliability, ranged from .85 to .95 across the nine subtests. Since the WRAT-3 consists of three forms, alternate form correlations on the raw scores for the reading, spelling, and arithmetic subtests were calculated and reported as .98, .98, and .98 respectively, which provide further evidence of the reliability of this instrument. Test-retest reliability coefficients on the nine tests ranged from .91 to .98. The standard errors of measurement are also provided for the standard scores, for each of the 23 age groups from the normative sample.

Test of Nonverbal Intelligence (2nd Edition) (TONI-2)

The TONI-2 (Brown, Sherbenou & Johnson, 1990) was used as a brief measure of cognitive ability to provide descriptive information on study participants. The TONI-2 is a language-free, motor-reduced, and culture-reduced measure of cognitive ability that involves abstract/figural problem solving intended for individuals ages 5 years through adulthood. The TONI-2 results may also be analyzed as covariate to determine the extent cognitive abilities may influence performance on other tests because most of the sensory-motor tasks are performance based and non-verbal, therefore only a measure of non-verbal abilities are of interest for this study. The TONI-2 requires approximately 15 minutes to administer which is one advantage of the tool. Two equivalent forms, Form A and Form B are provided. Form A was used in this study, as this is the form recommended by the test manual for the first TONI-2 administration. The test is administered and scored based on standardized procedures. Raw scores are converted to percentiles and quotient scores with a mean of 100 and a standard deviation of 15.

Evidence to support test content, criterion and construct validity is provided by several studies reported in the test manual (Brown et al., 1990). Test items were determined to be representative of the construct of language free cognitive abilities. Multiple studies also provide evidence that the TONI-2 is moderately to strongly related to other measures of intelligence. The two forms of the test are also strongly inter-correlated. In addition, several studies lend support for the notion that the TONI-2 accurately discriminates among groups of special populations of individuals including those with learning disabilities, head injuries, or gifted abilities. Finally, there is some evidence provided in the test manual that the TONI-2 is predictive of full scale IQ performance on more comprehensive measures of intelligence (e.g. Weschler Intelligence Scale for Children).

Several measures of test reliability were also reported in the test manual (Brown, et al., 1990). Mean coefficient alphas used to measure the TONI-2's internal consistency reliability were .95 on Form A and .96 on Form B. Immediate test-retest reliability with the two alternate forms of the TONI-2 also yielded a mean correlation coefficient of .86, while test-retest stability over one week was reported at .85. The test manual also reports test-retest reliability with several groups of children with disabilities. Median correlation coefficients in these studies were all reported above .80.

Data Analysis

The Statistical Package for Social Sciences (SPSS) version 10.0 was used to organize and analyze data. Descriptive statistics including raw scores, means, standard deviations, and high/low scores were used to summarize performance on each of the individual tests and selected subtests. Data were plotted with histograms and box plots for visual inspection. Multiple Analysis of Covariance (MANCOVA) was used to analyze differences between group means on selected primary variables. MANCOVA was selected to minimize the chance of inflated Type I error due to the multiple tests of significance on the primary dependent variables and to account for probable variance due to cognitive functioning. Chi-square tests for independence were used to analyze differences between categorical test results on selected variables. Significance levels for all analyses were set at .05 because of the exploratory nature of this study.

Follow-up repeated measures ANOVA was used to analyze subtest scores for three measures in this study, the SSP, NEPSY and SIB-R. The within-subjects repeated measures effect tested whether significant variance was accounted for across the subscales of selected instruments. In addition, it also tested for an interaction between group and repeated measures. Differences between the subtest mean by group interaction were tested individually when a statistically significant group by repeated measures occurred at the overall protected F-test level of analysis.

To examine the relationships between each of the primary measures of sensory processing and integration, adaptive behavior and school performance, scatter plots were used to visually inspect the data and determine the general distributions of the data. A Pearson-product moment correlation was used to analyze the relationships between each of the total test measures and selected subtests. Finally, the dependent variables were further explored using a discriminant function analysis to determine which measures of sensory-motor performance, school performance, and adaptive behavior discriminated between the groups of children with alcohol-related diagnoses and typical development.

Results

Demographic Information

Table 1 presents demographic information on all study participants as reported by the primary caregiver. The groups were compared by age, grade, gender, IQ, and racial/ethnic background. Results revealed no statistically significant differences related to age, gender, or racial/ethnic background. Thus, differences in outcome variables are not attributable to differences in these factors. The groups did differ significantly, however, by grade level, $\chi^2(5, N = 51) = 8.58, p < .05$. Several children with alcohol-related diagnoses were still enrolled in preschool or developmental preschool programs. In contrast, all of the children with typical development were enrolled in kindergarten through grade two. The groups also differed significantly by IQ as measured by the TONI-2, $t\ (49) = -1.74, p = 09$ (two-tailed).

Regarding family structure and caregiver status, only two children in the alcohol-related diagnoses group were living with a biological parent at the time of the study. The remaining 23 children were in other home placements (e.g. foster, adopt, guardianship). Chi-square analysis indicated that the two groups differed significantly by household structure $\chi^2(3, N = 51) = 40.26, p < .001$, but that they did not differ significantly by caregiver status. Attempts were made to track the level of maternal education, however, these data were felt to be unreliable and not reported due to the high number of children with alcohol-related diagnoses in adoptive homes, which resulted in inconsistent reports of the educational status of the biological versus adoptive mothers. No formal measures of socioeconomic status (SES) were included on the demographic questionnaire.

Table 2 presents a summary of the diagnostic features of the children with alcohol-related diagnoses in this sample, as well as other prenatal and postnatal risk factors based on the criteria described by Astley and Clarren (1999). Only 3 (12%) children in this sample had an actual diagnosis of Fetal Alcohol Syndrome (FAS) or Atypical FAS. The remaining children presented with a range of diagnostic characteristics (normal to severe) associated with alcohol-related diagnoses. Eight children had evidence of structural brain damage (e.g. microcephaly). Most of the children also had a history of a moderate to high degree of other prenatal risk factors (e.g. exposure to other drugs, no prenatal care) and postnatal risk factors (e.g. experienced physical abuse, neglect, multiple home placements).

Table 1

Participant Demographic Information

Variable	Alcohol-Related Diagnoses (n = 25)	Typical Development (n = 26)	p value
Gender			
Male	14 (56%)	14 (54%)	ns[b]
Female	11 (44%)	12 (44%)	
Age			
Mean	6.5 years (SD = .88)	6.9 years (SD = .85)	ns[a]
Range	5.0-8.0 years	5.3-8.5 years	
Racial/Ethnic Background			
Caucasian	12 (48%)	13 (50%)	ns[b]
African American	3 (12%)	2 (8%)	
Hispanic/Latino	1 (4%)	4 (15%)	
Native American	4 (12%)	0 (0%)	
Asian/Pac. Islander	1 (12%)	2 (8%)	
Other/Not Reported	4 (12%)	5 (19%)	
Caregivers in Household			
Single caregiver	8 (32%)	3 (12%)	ns[b]
Two caregivers	12 (48%)	17 (65%)	
Other/Not Reported	5 (20%)	6 (23%)	
Family Structure			
Biological parent/s	2 (8%)	19 (73%)	$\leq .001$[b]
Foster/guardianship	7 (28%)	1 (4%)	
Adoptive	16 (64%)	0 (0%)	
Other/Not Reported	0 (0%)	6 (23%)	
Grade			
Preschool	7 (28%)	0 (0%)	$\leq .05$[b]
Kindergarten	8 (32%)	10 (40%)	
Grade 1	7 (28%)	9 (36%)	
Grade 2	3 (12%)	7 (24%)	

[a] independent samples t test. [b] χ^2 analysis.
ns = not significant.

Table 2

Diagnostic Features of Children with Alcohol Related Diagnoses

Diagnostic Features	*n*	(%)
Growth		
1: None	19	(78%)
2: Mild	2	(9%)
3: Moderate	2	(4%)
4: Severe	2	(9%)
Face		
1: Normal	6	(24%)
2: Mild Facial Features	12	(48%)
3: Moderate Facial Features	1	(4%)
4: Severe Facial Features	6	(24%)
Brain		
1: None no evidence of damage[a]	0	(0%)
2: Possible (neurobehavioral disorder)	17	(68 %)
3: Probable (static encephalopathy)	0	(0 %)
4: Definite (static encephalopathy)	8	(32 %)
Alcohol		
1: No prenatal exposure[a]	0	(0%)
2: Unknown exposure[a]	0	(0%)
3: Alcohol exposed, quantity moderate or unknown	10	(40%)
4: Alcohol exposed, quantity high	15	(60%)
Prenatal Risk Factors		
1: No risk	0	(0%)
2: Unknown risk	1	(4%)
3: Some risk (e.g. no prenatal care, other drug exposure)	21	(84%)
4: High risk (e.g. other teratogens, genetic risk)	3	(12%)
Postnatal Risk Factors		
1: No risk	0	(0%)
2: Unknown risk	5	(20%)
3: Some risk (e.g. no prenatal care, other drug exposure)	13	(52%)
4: High risk (e.g. other teratogens, genetic risk)	7	(28%)

[a] Children with these ranks were not recruited for this study.

Descriptive Data and Group Comparisons

Descriptive statistics and MANCOVA results for each of the 13 primary dependent variables by group are presented in Table 3. Due to missing data, the sample sizes for the MANOVA were adjusted to include only children with complete data on all of the variables. The adjusted group sample sizes were as follows: children with alcohol-related diagnoses ($n = 20$), children with typical development ($n = 21$). Results indicated that the overall effect for group was significant, Wilks lambda $F(12, 26) = 6.65$, $p < .001$, with follow-up univariate tests indicating significant differences between group means on 10 of 13 dependent variables.

Given previous debate over whether IQ deficits versus prenatal alcohol exposure are responsible for differences in test performance and given the significant difference between groups on the TONI-2, MANCOVA was completed with the TONI-2 as a covariate. An overall effect with this covariate, Wilks lambda $F(12, 26) = 3.48$, $p = .004$ was seen. This suggests a significant IQ-related effect on these measures in these two groups of children. However, significant differences between groups remained on the same measures, even with this covariate accounted for in the analysis. Data met the assumptions for normality, homogeneity of variance-covariance matrices, linearity, and multicollinearity.

Table 3

Descriptive Statistics: Primary Test Score Variables by Group

	Alcohol-Related Diagnoses				Typical Development				
Test	*n*	*M*	*SD*	Lo/Hi	*n*	*M*	*SD*	Lo/Hi	p value ≤
SSP[a]	25	122.7	24.8	78-170	23	161.7	23.1	101-184	.000
BOTMP[c]	25	49.1	14.0	24-72	26	58.3	10.0	37-75	.001
QNST-II[a]	25	35.3	9.7	15-57	26	23.2	7.7	10-37	.000
NEPSY SM[b]	25	84.6	16.1	61-117	26	108.4	10.6	82-124	.000
NEPSY VP[b]	25	88.0	18.6	62-122	26	108.6	12.5	81-124	.000
TONI-2[b]	25	91.0	15.0	60-128	25	109.0	14.8	82-136	.001
SIB-R BI[b]	22	81.7	23.7	37-138	23	109.0	15.0	84-131	.000
WRAT-3 Read[b]	25	93.0	16.7	66-129	26	102.0	17.3	66-143	.116
WRAT-3 Spell[b]	25	86.0	16.6	53-124	26	100.7	12.5	78-122	.233
WRAT-3Math[b]	25	80.8	13.7	53-111	26	103.7	10.9	86-129	.000
SSRS Social[b]	21	96.8	14.4	67-124	22	101.4	10.8	83-128	.640
SSRS Behavior[b]	21	108.9	15.7	85-138	22	94.0	9.7	85-110	.007
SSRS Academ[b]	20	92.3	10.8	67-109	22	99.0	11.3	79-115	.014

[a]Raw Score. [b]Standard Score (*M* = 100; *SD* = 15). [c]Standard Score (*M* = 50; *SD* = 10).

Sensory Processing and Sensory-Motor Variables

Short Sensory Profile (SSP)

Scores for three of the children in the group with typical development were not available because the parents did not return the SSP form. The SSP mean Total Score was significantly lower ($p < .001$) and corresponded with the Definite Difference category for the group with alcohol related-diagnoses when compared to the mean Total Score of the group with typical development, which corresponded to the Typical Performance category. A lower score on the SSP Total Score and each of the sections indicates an increased frequency of problem behaviors.

The percent of children, by group, in each classification category (Typical Performance, Probable Difference, Definite Difference) of the SSP Total Score and each of the seven sections are presented in Table 4. Children from both groups were classified across each of the three classification categories on the Total Score. Children in the group with alcohol-related diagnoses (88%) were classified in the Probable and Definite Difference categories on the Total Score more frequently than children in the comparison group (30%). This suggests that some, although significantly fewer, children with typical development also demonstrated behavioral symptoms associated with sensory processing difficulties. Children from both groups were also classified in all three categories among the sections, with the exception of the Auditory Filtering section, in which no child with alcohol-related diagnoses scored in the Typical Performance classification category.

Significant differences between groups on the SSP classification categories as measured by chi-square tests for independence, were noted on the Tactile Sensitivity, Underresponsive/Seeks Sensation, Auditory Filtering, and Visual/Auditory Sensitivity sections. No significant group differences were noted on the Taste/Smell Sensitivity, Movement Sensitivity, or Low Energy/Weakness sections. It should be noted that the chi-square analyses were completed despite a maximum of 2 cells (33%) in four analyses with an expected count less than 5. Thus, there is a risk of larger chi-square values and the possibility of an inflated Type I error on the following subtests: Taste/Smell Sensitivity, Underresponsive/Seeks Sensation, Low Energy/Weak and Visual/Auditory Sensitivity.

The mean raw scores for each of the SSP section scores were lower for the group with alcohol-related diagnoses than the group with typical development. Descriptive data for the SSP section raw scores are presented in Table 5. A repeated measures ANOVA combining the seven SSP sections as one factor indicated a significant overall group by factor interaction; $F = 4.15$; p = .002, suggesting variability across the sections by group. Follow-up mean contrasts indicated a significant interaction, $F = 27.38$; p = .000 between the Underresponsive/Seeks Sensation (18.44) and Movement Sensitivity (11.88) sections when compared to the group with typical development (27.3) and (12.91), respectively. A significant interaction, $F = 4.06$; $p = .05$ was also noted between the Auditory Filtering (16.2) and Low Energy/Weakness (23.7) sections when compared to the group with typical development (23.2) and (27.9), respectively. This suggests that mean scores on the Underresponsive/Seeks Sensation and Auditory Filtering sections contributed significantly to the overall interaction pattern and contributed to the greatest amount of variability on this measure.

Table 4

Short Sensory Profile Classification Categories by Group

	Alcohol-Related Diagnoses (n = 25)			Typical Development (n = 23)			
Sensory Profile	Normal	Probable Difference	Definite Difference	Normal	Probable Difference	Definite Difference	p value ≤[a]
Total Score	3 (12%)	2 (8%)	20 (80%)	16 (70%)	2 (8%)	5 (22%)	.001
Tactile Sensitivity	8 (32%)	2 (8%)	15 (60%)	16 (74%)	2 (9%)	4 (17%)	.022
Movement Sensitivity	11 (44%)	5 (20%)	9 (36%)	14 (61%)	6 (26%)	3 (13%)	. 185
Taste/Smell Sensitivity	11 (44%)	4 (16%)	10 (40%)	17 (74%)	2 (9%)	4 (17%)	. 108
Underresponsive/ Seeks Sensation	3 (12%)	4 (16%)	18 (72%)	13 (57%)	4(17%)	6 (26%)	. 002
Auditory Filtering	0 (0%)	6 (24%)	19 (76%)	13 (57%)	5 (22%)	5 (22%)	.000
Low Energy/Weak	13 (52%)	1 (4%)	11 (44%)	18 (78%)	2 (9%)	3 (13%)	.060
Visual/Auditory Sensitivity	10 (40%)	4 (16%)	11 (44%)	19 (83%)	2 (9%)	2 (9%)	.004

[a] χ^2 analysis

Table 5

Descriptive Data for Sensory Profile Subtest Raw Scores

	Alcohol-Related Diagnoses[a]			Typical Development[b]		
Sensory Profile Subtests	*M*	Lo/Hi	*SD*	*M*	Lo/Hi	*SD*
Tactile Sensitivity	24.9	14-34	6.3	30.7	21-35	4.3
Movement Sensitivity	11.9	8-15	2.7	12.9	6-15	2.6
Taste/Smell Sensitivity	13.2	4-20	5.4	16.1	4-20	4.7
Underresponsive/Seeks Sensation	18.4	9-31	6.1	27.3	15-35	5.1
Auditory Filtering	16.2	10-22	3.9	23.2	17-30	3.8
Low Energy/Weak	23.7	9-30	6.1	27.9	19-30	3.4
Visual/Auditory Sensitivity	16.7	7-25	5.4	21.1	9-25	4.1

[a] ($n = 25$). [b] ($n = 23$).

Quick Neurological Screening Test-II: QNST-II

MANCOVA results indicated that the mean raw score of the QNST-II was significantly higher ($p < .001$) for the alcohol-related diagnoses group, which corresponded to the Moderate Discrepancy performance category than the mean raw score for the comparison group, which corresponded to the Normal performance category. A higher score on the QNST-II indicates more problematic performance. Descriptive statistics for this measure can be found in Table 3.

Each QNST-II raw score corresponds to one of the following classification categories: Normal, Moderate Discrepancy, or Severe Discrepancy. The percentages of children from each group in the QNST-II classification categories can be found in Table

6. For the purpose of calculating the chi-square test for independence, the Moderate and Severe Discrepancy categories were combined since only 1 (4%) child with an alcohol-related diagnosis and none of the children with typical development were classified in the Severe Discrepancy category. Significant differences between groups classified in the Normal verses Moderate/Severe Discrepancy Categories were noted, $\chi^2(2, n = 51) = 11.52, p < .05$. Overall, more children with alcohol-exposure (84%) scored in the Moderate and Severe Discrepancy performance categories than would be expected in this distribution. More children with typical development scored in the Normal performance category, however 28% of the children in this group scored in the Moderate Discrepancy category.

Table 6

QNST-II Classification Categories

Classification Category	Alcohol-Related Diagnoses ($n = 25$)	Typical Development ($n = 26$)
Normal	4 (16%)	16 (62%)
Moderate Discrepancy	20 (80%)	10 (28%)
Severe Discrepancy	1 (4%)	0 (0%)

Chi-square analysis was also used to determine group differences for the performance of children on each of the 15 items of the QNST-II. The children with alcohol-related diagnoses scored in the Moderate to Severe Discrepancy categories on each of the test items more frequently than children in the group with typical development.

For the purpose of calculating the chi-square test for independence, the Moderate and Severe Discrepancy categories were once again combined. Significant differences were noted between groups on the following six items: (a) figure recognition (design copying) χ^2 (1, $N = 51$) = 19.83, $p < .001$; (b) thumb-finger touching (fine motor coordination) χ^2 (1, $N = 51$) = 4.37, $p < .05$; (c) arm leg extension (postural control) χ^2 (1, $N = 51$) =18.12, $p < .001$; (d) tandem walk (dynamic balance) χ^2 (1, $N = 51$) =14.84, $p < .001$; (e) stand on one leg (static balance) χ^2 (1, $N = 51$) = 21.36, $p < .001$; and (f) behavior χ^2 (1, $N = 51$) = 6.95, $p < .01$. On the behavior and thumb-finger touching items, the expected cell count was less than expected in two cells (50%), thus there is a risk of an inflated chi-square ratio and Type I error for these two items.

Developmental Neuropsychological Examination (NEPSY)

Significant differences were noted between the children with alcohol-related diagnoses and the group with typical development on the mean standard scores of the NEPSY Sensorimotor Domain and the Visuospatial Processing Domain. The mean standard scores for both tests were lower for the alcohol-related diagnoses group than the comparison group. Descriptive data can be found in Table 3.

The mean standard scores for each of the core domain subtests were also lower for the group with alcohol-related diagnoses in comparison to the group with typical development. Descriptive data for the NEPSY subtests are presented in Table 7. A repeated measures ANOVA combining the five NEPSY subtests as one factor indicated an overall group by factor interaction; $F = 2.89$; $p = .02$, suggesting variability across the subtests by group. Follow-up mean contrasts indicated a significant interaction, $F = 9.68$;

p = .003 between the Design Copying (6.7) and Arrows (9.8) subtests when compared to the group with typical development (11.3 and 11.2) respectively. This suggests that mean scores on the Design Copying contributed significantly to the overall interaction pattern and accounted for the greatest amount of variability among the domain scores on the NEPSY.

Table 7

Descriptive Statistics: NEPSY Core Domain Subtest

NEPSY Subtests	Alcohol-Related Diagnoses ($n = 25$)			Typical Development ($n = 26$).		
	M	Lo/Hi	*SD*	*M*	Lo/Hi	*SD*
Sensorimotor Functions						
Fingertip Tapping[a]	8.5	2-13	3.4	12.0	9-15	1.7
Visual Motor Precision[a]	7.1	4-14	2.3	10.6	5-14	2.7
Imitating Hand[a]	8.2	4-12	3.1	10.4	4-14	2.3
Visuospatial Processing						
Design Copying[a]	6.7	1-16	3.8	11.3	6-17	3.5
Arrows[a]	9.8	4-16	2.8	11.2	6-15	2.4
Visual Attention[a]	8.7	3-16	3.4	10.7	7-16	2.4
Sensorimotor Functions Exp.						
Manual Motor Sequences[b]	30.8	2-43	10.3	38.0	23-55	8.1
Finger Discrim-Preferred[b]	13.7	9-18	2.5	15.2	7-18	2.3
Finger Discrimin-Non Preferred[b]	12.9	6-18	3.2	15.0	11-18	2.0

Note. [a]Subtest standard scores (mean = 10; SD = 3). [b]Subtest raw scores.

Three subtests of the NEPSY (Finger Discrimination Preferred, Finger Discrimination Non-Preferred, and Manual Motor Sequences) yielded categorical results. Raw scores were converted to categories based on percentile rank. Five categories were reduced to the following three categories for this analysis: 1) well below to below expected level (< 10^{th} percentile), 2) borderline (10^{th} –25^{th} percentile), and 3) at to above expected level (> 25^{th} percentile). Chi-square analysis yielded significant differences between groups on the tests of Finger Discrimination Preferred $\chi^2(2, N = 51) = 7.21, p < .05$ and Finger Discrimination Non-preferred $\chi^2(2, N = 51) = 6.34, p < .05$. No significant differences between groups were noted on the Manual Motor Sequences subtest $\chi^2(2, N = 50) = 3.31, p > .05$. The expected cell count on each of these analyses was less than expected (33% to 67%), thus there is a risk of inflated Type I error with these results. The mean raw scores on all three of these subtests were lower for the group with alcohol-related diagnoses. Finally, although the NEPSY contains a number of qualitative observations for specific test items, data from these items were considered unreliable and therefore excluded from the analysis.

Bruninks-Oserteskv Test of Motor Proficiency-Short Form (BOTMP)

Statistically significant differences ($p < .001$) were noted between groups on the BOTMP. The mean standard score for children with alcohol-related diagnoses (M = 49.10; SD = 13.95) was lower then the mean standard score of the children with typical development (M = 58.28; SD = 10.0). The mean standard scores for both groups were within the average range in comparison to the test norms.

Adaptive Behavior and School Performance Variables

Scales of Independent Behavior-Revised (SIB-R)

Scores for three of the children in the group with typical development were not available because the parents did not return the SIB-R form. Table 8 summarizes descriptive statistics for the Broad Independence Score and four subtest scores.

Table 8

Descriptive Data for the SIB-R Total Score and Subtests

SIB-R	Alcohol-Related Diagnoses (*n* = 25)			Typical Development (*n* = 23)		
	M	Low/Hi	*SD*	*M*	Low/Hi	*SD*
Broad Independence	81.68	37-138	23.65	107.39	84-131	13.89
Motor	91.52	40-133	23.57	110.30	78-146	17.17
Social Interact/ Comm.	84.36	33-126	20.09	107.56	74-141	15.74
Personal Living Skills	85.72	37-131	22.03	108.48	78-135	16.40
Community Living Skills	76.80	34-130	20.98	97.09	64-123	14.09

Note. Based on standard scores ($M = 100$; $SD = 15$)

A significant difference between groups was noted on the mean standard score for the SIB-R Broad Independence Scale. The mean standard score of the SIB-R Broad Independence Scale was significantly lower for the group with alcohol-related diagnoses than the group with typical development. The mean scores on each of the four subtests, Motor, Social Interaction and Communication Skills, Personal Living Skills and Community Living Skills were also lower for the group with alcohol-related diagnoses. The Motor Skills scale yielded the highest mean scores for both groups; whereas, the Community Living Skills scale yielded the lowest mean scores. Repeated measures ANOVA combining the four SIB-R scales as one factor did not indicate an overall group by factor interaction, therefore, post hoc follow up contrasts were not completed.

Significant differences between groups on all four indices of the SIB-R Maladaptive Behavior Indices were also indicated by chi-square analysis. Results are presented in Table 9. Two caregivers with children in the alcohol-related diagnoses group did not complete this section of the SIB-R; therefore, results for the alcohol-related diagnoses group are based on 23 participants. For the purpose of this analysis the five descriptive categories were combined into three categories "Normal," "Marginally Serious," and "Moderate to Serious." Children in the group with alcohol-related diagnoses scored in the Marginally Serious to Moderate/Serious Categories more frequently than children with typical development. No children in the group with typical development scored in the moderately severe or serious categories. No child in either group scored in the Very Serious category.

Seventy-eight percent of children with alcohol-related diagnoses, in contrast to 4% of children with typical development were identified with behavioral difficulties on the SIB-R General Maladaptive Behavior Index. Forty-three percent to 56% of children with alcohol-related diagnoses demonstrated concerning scores on the Internalized, Externalized, and/or Asocial Maladaptive Indices as compared to only 4% to 9% of the children in the comparison group.

Table 9

SIB-R Maladaptive Behavioral Indices

Index Category	Alcohol-Related Diagnoses	Typical Development	*p* value ≤
General Maladaptive			.001[b]
Normal	5 (22%)	22 (96%)	
Marginally Serious	10 (44%)	1 (4%)	
Moderate to Serious	8 (34%)	0 (0%)	
Internalizing			.001[a]
Normal	11(47.8%)	23 (100%)	
Marginally Serious	6 (26%)	0 (0%)	
Moderate to Serious	6 (26%)	0 (0%)	
Externalizing			.006[a]
Normal	13 (57%)	22 (96%)	
Marginally Serious	3 (13%)	1 (4%)	
Moderate to Serious	7 (30%)	0 (0%)	
Asocial			.004[a]
Normal	10 (43%)	21 (92%)	
Marginally Serious	4 (17%)	2 (9%)	
Moderate to Serious	9 (39%)	0 (0%)	

Note. $n = 23$ for each group.
[a]Chi-square test for independence with 4 cells (66%) with and expected count less than 5.
[b]2 cells (33%) with an expected count less than 5.

Wide Range Achievement Test (WRAT-3)

The mean scores of the group of children with alcohol-related diagnoses were lower than the children with typical development across the WRAT-3 subscales. A statistically significant difference between the two groups was noted only on the Math scale ($p < .001$). There were no significant differences between groups on the Reading or Spelling scales.

Social Skills Rating Scale (SSRS)

Return rates for this measure were slightly lower than the other measures in this study. Scores were available for 21 (84 %) children with alcohol-related diagnosis and 23 (88%) children with typical development. Norms for children with handicaps were used for 14 (67%) of the children with alcohol-related diagnoses who were receiving special education services and had completed forms. No children in the comparison group were receiving special education services. Descriptive statistics and MANCOVA results for the SSRS scales are presented in Table 3. Significant differences between group means were noted on the Problem Behaviors scale ($p < .01$) and the Academic Competence scale ($p < .05$). No significant differences were noted between groups on the Social Skills scale. A higher standard score on the Problem Behaviors scale suggests increased behavioral difficulties, whereas, a higher standard score on the Social Skills or Academic Competence scale indicates increased skills or competence levels.

Categorical analysis was completed for the descriptive behavior levels under each of the three SSRS scales. Significant group differences were noted only for the Problem Behavior level categories $\chi^2(2, N = 43) = 11.24, p < .01$, although results should be interpreted carefully, as 3 cells (50%) had an expected count less than 5, thus a risk of inflated Type I error. Five children (25%) in the alcohol-related diagnoses group were classified with "more than average" behavior problems, whereas none of the typically developing children were classified in this category. Nine of the children with typical development (39%) were classified as having "fewer than average" behavior problems, whereas only one child (5%) in the group with alcohol-related diagnoses was classified in this category. The remaining children in both groups had an "average" number of behavior problems. No differences were noted between groups for the Social Skills behavior levels or the Academic Competence behavior level.

Test of Non-Verbal Intelligence-2 (TONI-2)

There was a significant difference between group means on the TONI-2 as presented in Table 3. Children in the comparison group scored on average 18 points higher than the group with alcohol-related diagnoses, however, the mean standard score for both groups was in the "average" range of performance based on the test norms. Six of the participants (24%) in the alcohol-related group scored below 85 (one standard deviation from the mean), whereas only one participant (4%) in the comparison group scored below this level.

Correlations Between Primary Test Variables

Table 10 presents the Pearson product moment intercorrelations between the 13 primary outcome variables across the total sample of children. Numerous moderate correlations among measures were noted. Correlations significant to the $p < .05$ level are discussed with an emphasis on the sensory-motor measures, as these variables are the most interesting from a theoretical perspective in this study. As a general guideline, the following recommendations by Portney and Watkins (2002) were used to interpret the strength of the correlation. Correlations ranging from 0.00 to .25 suggest little or no relationship; .25 to .50 suggest a fair degree of relationship; values of .50 to .75 are moderate to good, and values above .75 are considered good to excellent.

A moderate correlation between the SSP and the SIB-R Broad Independence Scale (r = .58) was noted, which was the highest correlation of the SSP with any measure. A fair degree of relationship was indicated for the SSP and other measures of sensory-motor performance on the NEPSY Sensorimotor (r = .33) and Visuospatial Processing Core Domains (r = .39), as well as academic performance on the WRAT-3 Math scale (r = .33). The SSP was negatively correlated with the QNST-II (r = -.33).

The QNST-II was, as expected, moderately correlated with measures of motor performance (BOTMP $r = -.68$) and sensory-motor performance (NEPSY Sensorimotor and Visuospatial Processing subtest, $r = .68$ and .70). Stronger relationships with the WRAT-3 Math Scale ($r = -.63$) and somewhat weaker, but significant relationships with the WRAT-3 Reading ($r = -.32$) and Spelling ($r = -.38$) Scales were also noted.

The two NEPSY core domains were moderately correlated with academic achievement on the WRAT-3 ($r = .34$ to .72) with the strongest relationship noted between the NEPSY Visuospatial Processing Domain and the WRAT-3 Math Scale ($r = .72$). The SIB-R Broad Independence score was fairly to moderately correlated with all measures ($r = .35$ to .64) with the exception of the SSRS subscales. Likewise the TONI-2 was moderately correlated with all measures with the exception of the SSP, WRAT-3 Spelling, and the Social Skills and Problem Behaviors scales of the SSRS.

As expected subscales of the SSRS were moderately correlated with each other (*r* = -. 34 to .64) but there were limited relationships with other measures. The Academic Competence subscale had significant relationship with three measures: the TONI-II (*r* = .43), WRAT-3 Math (*r* = .40), and the BOTMP (*r* = .35). A small negative correlation was noted between the Problem Behaviors scale and the WRAT-Math scale (*r* = -.36), the negative correlation is due to the direction of the standard scores, thus as math performance decreased, problem behaviors increased.

Table 10

Correlation Matrix for Primary Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. SSP	--	-.33*	.16	.33*	.39**	.58**	.35*	.13	.20	.33*	-.17	-.24	.20
2. QNST-II		--	-.68**	-.68**.	-.70**	-.55*	-.62**	-.32*	-.38**	-.63**	.01	.28	-.30
3. BOTMP			--	.64**	.60**	.48**	.50**	.48**	.32*	.57**	.09	-.13	.35*
4. NEPSY SM				--	.66**	.67**	.68**	.34**	.38**	.57**	-.00	-.28	.27
5. NEPSY VM					--	.60**	.71**	.37**	.43**	.72**	-.08	-.15	.28
6. SIB-R BI						--	.54**	.39**	.35**	.64**	-.03	-.30	.22
7. TONI-2							--	.19	.33*	.58**	.13	-.26	.43*
8. WRAT-3 Spell								--	.54**	.48**	.06	-.07	.28
9. WRAT-3 Read									--	.48**	-.06	.07	.26
10. WRAT-3 Math									--	--	.17	-.36*	.50**
11. SSRS Social											--	.61**	.56**
12. SSRS Behav												--	-.43**
13. SSRS Academ													--

* Sig. at .05 level (two-tailed). **Sig. at .01 level (two-tailed).

Discriminant Function Analysis

Three separate discriminant function analyses were completed for the primary 1) sensory-motor 2) adaptive behavior and 3) academic performance variables. Analyses were run separately to avoid over-identifying variables. Variables for each analysis were entered stepwise and ordered by the absolute size of correlation within function. Weaker variables were removed from the analysis. Tables 11-13 present a summary of pooled within group correlations and canonical discriminant functions for each of the three groups of variables. Statistically significant canonical discriminant functions contrasting children with alcohol-related diagnoses with children with typical development at the .05 level were noted in each of the three groups. Table 14 presents the stepwise summary for each of the three discriminant function analyses.

Using the SSP and NESPY Sensorimotor domain, 88% of the cases were correctly classified in the first discriminant analysis that included the sensory-motor variables. A second analysis on academic performance variables using the WRAT-3 Math scale correctly classified 80% of the cases. Finally, a third analysis of adaptive behavior using the SIB-R Broad Independence Scale and the SSRS Problem Behavior subscale correctly classified 85% of the cases. These results suggest high rates of classification accuracy for the measures in each of the three analyses.

Table 11

Pooled Within Group Correlations between Sensory-Motor Variables and Canonical Discriminant Functions

Dependent Variables	Canonical Correlations
NEPSY SM	.716
SSP	.600
NEPSY VP[a]	.457
BOTMP[a]	.434
QNST[a]	-.389

Note. [a]Indicates variables removed from the analysis.

Table 12

Pooled Within Group Correlations between Academic Performance Variables and Canonical Discriminant Functions

Dependent Variables	Canonical Correlations
WRAT Math	1.0
WRAT-Read[a]	.417
TONI-2[a]	.413
WRAT Spell[a]	.405

Note. [a]Indicates variables removed from the analysis.

Table 13

Pooled within Group Correlations between Adaptive Behavior Variables and Canonical Discriminant Functions

Dependent Variables	Canonical Correlations
SIB BI	.827
SSRS Problem	-.523
SSRS Social[a]	.191
SSRS Academic[a]	.190

Note. [a]Indicates variables removed from the analysis.

Table 14

Summary of Discriminant Function Analysis

Dependent Variables	*F*	*df*	*p* value ≤
Sensory-Motor			
Step 1	37.08	1, 46	.001
NEPSY SM			
Step 2	35.36	2, 45	.001
SSP			
NEPSY SM			
Academic Performance			
Step 1	26.88	1, 48	.001
WRAT-3 Math			
Adaptive Behavior			
Step 1	30.39	1, 37	.001
SIB-BI			
Step 2	21.65	2, 36	.001
SIB-BI			
SSRS Problem Behavior			

Discussion

The findings of this study will be discussed relative to performance differences between children with alcohol-related diagnosis and children with typical development across the following domains: 1) sensory processing, 2) sensory-motor performance, 3) adaptive behavior, and 4) school performance. Application of these findings as well as consideration of the relationships between key variables and functional performance within the evolving theoretical framework of sensory integration will also be discussed. Finally, the educational and diagnostic implications of these results, the strengths and limitations of this study, and directions for future research will be highlighted

Sensory Processing and Sensory-Motor Performance

Results from this study indicated that children with alcohol-related diagnoses performed significantly more poorly across measures of sensory processing and sensory-motor performance than children with typical development. Evidence for this included significantly lower mean scores on the BOTMP and the NEPSY Sensorimotor and Visuospatial Processing domains. In addition, children with alcohol-related diagnoses demonstrated significantly elevated mean scores and were more frequently classified in categories that suggested at-risk or problematic performance on the SSP and QNST-II. A discriminant function analysis indicated that the SSP and the NEPSY Sensorimotor domain were particularly strong variables that discriminated between these two groups of children.

Short Sensory Profile

The SSP suggested that caregivers of children with alcohol-related diagnoses reported more behavioral indicators of sensory processing differences than caregivers of children with typical development. Eighty-eight percent of children with alcohol-related diagnoses, in comparison to 30% of children with typical development, were classified in the Probable or Definite Difference category on this measure. Results from this study lend support for anecdotal reports of sensory processing and integration difficulties in this population and are consistent with previous findings by Morse et al. (1995) who found sensory processing difficulties 2 to 6 times higher in children with FAS/FAE than children with typical development. This study further strengthens these findings because it addressed previously noted limitations by using a published, standardized measurement tool (i.e. the SSP) and a more rigorously matched comparison group.

In addition to the Total Score, children with alcohol-related diagnoses scored in the Probable and Definite Differences category more frequently than the comparison group across the seven SSP sections. Significant differences between groups were noted on four of the seven SSP sections: Tactile Sensitivity, Auditory Filtering, Visual/Auditory Sensitivity, and Underresponsive/Seeks Sensation. Morse et al. (1995) also reported differences in these sensory domains with the exception of the Underresponsive/Seeks Sensation domain, which did not appear to be measured as a separate category in their study.

The Underresponsive/Seeks Sensation and Auditory Filtering sections were the most concerning domains for children with alcohol-related diagnoses. The highest number of children with alcohol-related diagnoses were classified in a Probable or Definite Difference category on these two sections. In addition, no child in the alcohol-related diagnoses group scored in the Normal category on the Auditory Filtering section These two sections also contributed to most of the variability and the significant interaction between all of the subtests on the SSP based on repeated measures ANOVA.

Such findings suggest that children with alcohol-related diagnoses frequently demonstrated behaviors associated with poor sensory modulation (Dunn, 1999). For example, they were reported as distractible to sounds with a decreased ability to filter competing auditory stimuli (e.g. "Is distracted or has trouble functioning if there is a lot of noise around"). They also demonstrated decreased awareness or sensitivity to some types of sensory input with a tendency to exhibit the need for increased intensity or duration of certain types of sensory input (e.g. "Doesn't seem to notice when face or hands are messy," "Seeks all kinds of movement and this interferes with daily routines"). Defensiveness and discomfort in response to touch, particularly light touch during social interactions and daily routines, as well as difficulty with visual and auditory input were also reported to occur frequently.

It should also be noted, however, that 30% of children with typical development in this sample were also classified in the Probable Difference or Definite Difference category on their SSP Total score, and 10% to 44% were classified in the Probable or Definite Difference category across each of the seven sections. Additionally, although the highest number of children with alcohol-related diagnoses demonstrated concerns on the Auditory Filtering and Underresponsive/Seeks Sensation sections, almost half (44%) of the children with typical development also scored in a Probable or Definite Difference category on these sections.

This suggests that sensory processing differences, as measured by the SSP, also occurred in children classified as typically developing in this sample. Alternatively, this might suggest that the SSP, particularly because it is a short form or a screening tool, has the potential to over identify children with sensory processing differences. Additionally, the high rate of children in the group with typical development who were also classified in concerning categories on the Underresponsive/Seeks Sensation and Auditory Filtering subtests suggests that such behaviors may not be atypical for many children in this age range.

One potential limitation of the SSP is that it does not have age-adjusted norms. Only the long form of the Sensory Profile (Dunn, 1999) has adjusted norms for three to four year-old children. While age effects were considered in the test development process (Dunn, 1999) and the selected items on the short form were the items that discriminated most between children with and without disabilities (McIntosh et al., 1999) the findings in this study suggest the possibility of developmental or age-related effects that should be carefully considered in the clinical interpretation of SSP results and when conducting future research studies.

Developmental Neuropsychological Examination

Significant differences between the mean group standard scores on the NEPSY Sensorimotor and Visuospatial Processing core domains were noted. Children with alcohol-related diagnoses had decreased mean scores that were skewed towards the low average range on both subtests with slightly weaker performance on the Sensorimotor Domain than the Visuospatial Processing Domain. These findings suggest subtle differences in the ability to process tactile information, coordinate hand and finger movements, and use a pencil with speed and precision. Low average scores and weaker performance on Sensorimotor foundational skills were similar to findings previously described by Fulks and Harris (1996) in preschool children with prenatal substance exposure.

The significant difference on the Visuospatial Processing domain was consistent with the findings of Korkman et al. (1998). In contrast to Korkman et al., however, differences between the sample of children with alcohol-related diagnoses and the comparison group were also significant on the Sensorimotor domain. Interestingly, results from the discriminant function analysis suggested that the Sensorimotor domain was a particularly strong measure in this study, as it demonstrated the potential to differentiate this group from children with typical development.

Children with alcohol-related diagnoses in this sample also had lower mean scores across the core domain subtests than the comparison group. These findings were consistent with those reported by Korkman et al. (1998), however the specific pattern of scores between the two samples of children with alcohol-related diagnoses varied. Children in this sample demonstrated higher mean scores on the Arrows, Visual Attention and Imitating Hand Positions subtests and lower mean scores on the Fingertip Tapping, Visuomotor Precision and Design Copying subtests when compared to the group in the Korkman et al. sample.

The contrast in findings from the Sensorimotor Domain and other subtests could be explained by different characteristics of the children in the two studies. The mean age of the children in this study was 6.9 years; the mean age in the Korkman et al. (1998) study was 9.2 years. In addition, children in this study presented with a wider range of IQ scores; 76% of the participants with alcohol-related diagnoses had IQ's above a standard score of 80, whereas all subjects in the Korkman study had IQ scores above 80.

Children with alcohol-related diagnoses performed below one standard deviation from the mean on only one subtest, Design Copying, in the Visuospatial Processing Domain. Based on repeated measures ANOVA and follow-up mean contrasts of the NEPSY subtests, the Design Copying subtest contributed to most of the variability and differences between groups on the NEPSY. This suggests that the Design Copying subtest, a task of visuomotor integration, may be more sensitive to group differences and the difficulties experienced by children with alcohol-related diagnoses. Additionally, on the Sensorimotor domain, the group with alcohol-related diagnoses performed most poorly on the Visuomotor Precision subtest ($M = 7.1$). Both of these tests involve fine and visual motor tasks that require increased motor control and coordination. These results are consistent with previous findings that have reported decreased fine and visual-motor abilities in children with alcohol-related diagnoses (Admans et al., 2001; Mattson et al., 1998).

On the three expanded Sensorimotor Functions items, the mean raw score for each item was lower for the alcohol-related diagnoses group. Despite a higher number of children classified in concerning categories on all three items, only differences on the

Finger Discrimination items (preferred and non-preferred) were significant. This suggests that children with alcohol-related diagnoses demonstrated decreased abilities to discriminate tactile information. No significant differences were noted on the Manual Motor Sequences item, thus motor planning and sequencing abilities as measured by this task were comparable across both groups.

Quick Neurological Screening Test-II

Children with alcohol-related diagnoses demonstrated poorer performance on the QNST-II, thus demonstrating a higher number of developmental or neurological soft signs than peers with typical development. Only one child in the group with alcohol-related diagnoses scored in the Significant Discrepancy category, while the highest percentage of children (80%) were classified in the Moderate Discrepancy category. Children with alcohol-related diagnoses, therefore, did not demonstrate severe, distinct neurological or motor impairments, but instead one or more subtle symptoms indicative of immature or qualitatively poor neuromotor performance (e.g. difficulty with balance, the inability to smoothly coordinate fine motor movements, poor or irregular figure copying, etc.). Such findings are consistent with those of Larrouque & Kaminski (1998) who found higher rates of minor neurological soft signs in preschool children prenatally exposed to alcohol and Marcus (1987) who described multiple neurologic soft signs in five children with FAS on neurological examination. Larrouque & Kaminski reported these findings with children with histories of higher levels of prenatal alcohol exposure.

Despite the statistically significant difference between groups, children in the comparison group also demonstrated evidence of neurological soft signs or developmental immaturities. The mean raw score (*M* = 23.5) for this group was just below the clinical cut off for classification in the Moderate Discrepancy category. In addition, just over one fourth (28%) of the children with typical development had scores that placed them within the Moderate Discrepancy category. This suggests that caution should be used when interpreting results with younger children, and as suggested by previous researchers, there may be developmental or age-related influences to consider when interpreting results from this measure (Ardilla & Roselli, 1996; Mutti et al., 1998). This also supports the clinical notion that this tool should be used for screening and descriptive, rather diagnostic purposes.

Although neurological soft signs are best interpreted as a cluster of clinical findings (Mutti, et al., 1998) a better understanding of specific deficits, by test item, may help inform clinical practices or be useful for descriptive purposes. Children with alcohol-related diagnoses performed significantly more poorly on the following items of the QNST-II: figure recognition (design copying), thumb-finger touching (fine-motor coordination), arm leg extension (postural control), tandem walk (dynamic balance), stand on one leg (static balance), and behavior. This suggests that these test items may be more sensitive to deficits related to prenatal alcohol exposure. Such results are consistent with other results from this study as well as previous findings reported by Roebuck et al., (1998) related to impaired balance and postural responses, and general findings related to decreased visual motor integration and fine motor coordination (Mattson et al., 1998).

Bruninks Oseretsky Test of Motor Proficiency

Children with alcohol-related diagnoses performed significantly lower on the BOTMP when compared to the children with typical development. However, the mean standard score for both groups was within one standard deviation of the test mean (M = 50; SD = 10). Inspection of individual test scores indicated that approximately one fourth of the children with alcohol related diagnoses scored below –1.00 SD from the mean suggesting that a smaller group of children had poorer performance. Interestingly, when the children with alcohol-related diagnoses were separated into two groups based on their diagnostic brain score, the mean score dropped significantly (M = 34.9) for participants with a Brain 4 in comparison to those with a Brain 2 (M = 54.1) and children with typical development (M = 57.2).

Overall results from this measure suggested "average" motor performance for children with alcohol-related diagnoses. This sample of children performed somewhat better than a group of school-aged children in a previous study where low average performance on this measure was indicated (Kyllerman et al., 1985). In addition to low average abilities, Kyllerman et al. also described qualitative differences in the speed and efficiency of motor skills that seemed to further describe the performance of children with prenatal alcohol exposure. Although qualititative differences were not specifically accounted for on this measure, one could speculate that a significant difference in mean group scores and decreased performance on other motor-related measures (e.g. QNST-II) in this study suggested discrepant performance from typically developing peers. Additionally, one limitation to the short form of the BOTMP is that is does not discriminate between fine verses gross motor abilities. Therefore, this measure may not have been sensitive or specific enough to detect the fine motor deficits described in this population. For example, Admans et al. (2001) described deficits in fine motor performance, but adequate gross motor skills in 6- to 8-year-old children with FAS. Finally, one could also cautiously surmise that there is a subgroup of children with prenatal alcohol exposure that demonstrates more severe motor difficulties, which may be related to their neurological status.

Adaptive Behavior

As expected, children with alcohol-related diagnoses had significantly lower mean scores on the SIB-R Broad Independence Scale, a composite measure of adaptive behavior, when compared to children with typical development. Lower mean scores were also noted across the four SIB-R subscales. The SIB-R Broad Independence Scale was a particularly strong measure in terms of its ability to discriminate between children with and without alcohol related diagnoses in this study.

Despite lower mean scores for the children with alcohol-related diagnoses on the four subscales of the SIB-R, a significant group by factor interaction with the repeated measures ANOVA was not found. Thus, it was not feasible to determine which subtests explained the variability and differences between the two groups. In general, however, mean scores for the subtests followed similar trends for each group (e.g. mean scores were highest on the Motor subtest and lowest on Community Living subtest). Further examination of the descriptive statistics for the SIB-R subtest scores also indicated considerable variability in both the range and standard deviation for children in the alcohol-related diagnoses group in comparison to children with typical development. This may have limited the statistical findings of these measures.

Surprisingly, the mean standard scores on the SIB-R Broad Independence scale and the subtests (M = 76.8 to 91.52) in this sample of children with alcohol-related diagnoses were higher than scores from other adaptive behavior measures, such as the Vineland Adaptive Behavior Scales (VABS), found in other studies (Streissguth et al., 1996; Thomas et al., 1998; Whaley et al., 2001). There are several possible explanations for this. First, there were some limitations with the use of the SIB-R as checklist instead of an interview. A few of the children in both groups also scored spuriously high, therefore one could question the reliability of these results (e.g. whether there was some misunderstanding of some of the questions, or whether there was some reporting bias in terms of wanting a child to look good). While the interview format would have allowed some additional parent guidance interpretation of the questions, limited time and examiner availability prohibited the use of this administration format for this study. Secondly, the SIB-R in general, may be a less sensitive measure of adaptive behavior. The SIB-R was specifically selected because it included a motor skills domain, which is not available on the VABS after 5 years of age (Sparrow et al., 1984). Results from the motor skills domain did not, however, yield particularly informative results; therefore, despite inclusion of a motor domain the value of this tool with this population is questionable, particularly when administered in the checklist format.

Results from the Maladaptive Behavior Indices of the SIB-R lend support for previous findings that indicated high rates of behavioral and psychosocial difficulties among children with alcohol-related diagnoses (Coles et al., 1991; Olson et al., 1998; Roebuck et al., 1999; Steinhausen & Spohr, 1996). Seventy-eight percent of children with alcohol-related diagnoses, in contrast to only 4% of children with typical development in this study were identified with behavioral difficulties on the General Maladaptive Behavior Index. Children with alcohol-related diagnoses also demonstrated more behavior problems across the other three behavioral indices; 43% to 56% of children with alcohol-related diagnoses were rated as problematic on the Internalized, Externalized and/or Asocial Indices as compared to only 4% to 9% of the children in the comparison group. Thus children with alcohol-related diagnoses in this sample demonstrated variable behavioral profiles, rather than one consistent behavioral pattern, as previously described in other studies (Coles et al., 1991).

School Performance

WRAT-3

Children with alcohol-related diagnoses showed lower mean score across the WRAT-3 academic measures, however, significant differences between groups were noted only the Math scale. There were no significant differences between groups on the Reading and Spelling scales. Findings from the WRAT-3 are consistent with previous research that suggested decreased math performance at age 7 (Streissguth et al., 1990) and later at 14 years of age (Streissguth et al., 1994) in children with FAS and FAE. The WRAT-3 Math scales also discriminated strongly between groups. Interestingly, the math scale had the strongest and most consistent relationships with other measures of behavior and sensory-motor abilities in this study. A previous study by Parham (1998) also pointed out the significant relationship between sensory integration and math abilities in young children.

Social Skills Rating Scale

Based on teacher report, children with alcohol-related conditions were rated more poorly on the Problem Behavior and Academic Competence Scales of the SSRS. Teachers identified significantly more behaviors that were indicative of externalizing, internalizing and hyperactivity-related problems in the group of children with alcohol-related diagnoses, even with the use of handicapped norms. They also indicated decreased levels of academic competence. It is important to note that this measure of academic competence is not based on formal grades or performance-based assessment, but rather an estimate of skills based on the teacher's judgment in comparison to other students in the class. Nonetheless teachers noted early academic differences, which are consistent with previous reports of poor teacher-rated academic performance (Olson et al., 1992). Interestingly, only a slightly higher, but not significant, mean score was noted for the children with typical development relative to the group with alcohol-related diagnoses on the Social Skills scale.

Several important issues need to be considered when interpreting the results from both of these measures. First, grade level was a significant variable that may have impacted results. Just over one-fourth (28%) of the children in the alcohol-related diagnosis were still in preschool programs, thus grade alone could account for differences in these findings. Second, the SSRS teacher rating scale is for children in grades K-6, however this scale was still used with the students in preschool as the Preschool version of the SSRS is normed for children 3 years to 4 years 11 months of age. Third, the return rate for the SSRS, particularly for the children with alcohol-related diagnoses, was lower than the other measures. Finally, handicapped norms were used for over two-thirds (67%) of the children in the alcohol-related diagnoses group on the SSRS. All of these factors may decrease the validity of these findings, particularly when one considers the mixed educational status of the children with alcohol-related diagnoses. Some of the children were being compared with children in special education programs, while others were being compared with children in regular education classrooms.

Because of this caveat, the SSRS was also analyzed based on the use of typically developing norms for all of the children in the alcohol-related diagnoses group. The SSRS raw scores can be transformed to standard scores based on either handicapped or nonhandicapped norms, and since the test manual provides unclear guidance for children with variable backgrounds, both analyses are reported for comparative purposes. Table 15 presents a summary of the SSRS mean scores and the adjusted means scores for the group with alcohol-related diagnoses, as well as the mean scores for the children with typical development.

Table 15

SSRS Adjusted Mean Standard Scores

SSRS Subscales	Alcohol-Related Diagnoses[a] ($n = 21$)	Alcohol-Related Diagnoses ($n = 21$)	Typical Development[b] ($n = 23$)
Social Skills[c]	90.8 (12.6)	96.2 (13.9)	101.4 (10.8)
Problem Behaviors[c]	114.7 (14.4)	108.9 (15.6)	94.0 (9.7)
Academic Competence[c]	85.3 (10.8)	92.3 (10.8)	99.0 (11.3)

Note. [a]SSRS Nonhandicapped norms [b]SSRS Handicapped norms [c]*M* (SD)

With this adjustment, standard scores shifted in the expected direction. Mean scores increased for the Problem Behavior Scales and decreased for the Social Skills and Academic Competence Scales. Subsequently, MANCOVA univariate F-tests showed a significant different between children with typical development and children with alcohol-related diagnoses (based on typically developing norms) on all of the SSRS scales. Most notably, there was a previously undetected significant difference on the Social Skills Scale ($p < .05$), while the Problem Behavior Scales ($p < .001$), and Academic Competence Scales ($p < .001$) remained significant. This suggests that teacher reported social skills were significantly different when children with alcohol-related diagnoses were compared with typically developing children, however, they were not different in comparison to other children with disabilities.

Test of Non-Verbal Intelligence-2

The mean score for children with alcohol-related diagnoses was significantly lower compared to children with typical development, and as in other measures in this study, the overall TONI-2 mean scores were within an average range for both groups. The cognitive performance of the children with alcohol-related diagnoses in this study was relatively consistent with previous finding that report variable performance from the above average to well below average range (Mattson & Riley, 1998). The mean score (*M* = 91; range = 60-128) of the sample in this study was more consistent with a group of individuals with FAE (*M* = 90; range 42-142), reported by Streissguth et al. (1996) than those with FAS (*M* = 79).

The TONI-2 was primarily included as an estimate of cognitive abilities in this study, and while it was a significant covariate, it is important to emphasize that this tool is not a comprehensive measure of cognitive abilities, but rather a brief measure of non-verbal abilities. In addition, it is important to remember that children with previous evidence of IQ scores below 60 were excluded from this study. Therefore, generalization about the broader cognitive performance of this sample of children to other children with FAS and alcohol-related diagnoses is somewhat limited.

<u>Relationships Between Primary Test Variables</u>

Sensory processing and integration is an evolving theoretical framework. The relationship of these factors with various behaviors and their relevance to educational performance and practices has often been unclear and controversial. Therefore in this study, it was also important to explore the theoretical relationships between sensory processing and sensory-motor variables with measures of higher-level learning, adaptive behavior, and social-academic functions (Ayres, 1972; Fisher & Murray, 1991; Parham & Mailloux, 2001).

In this study, sensory processing as measured by the SSP was moderately correlated with adaptive behavior as measured by the SIB-R. However, it was not significantly correlated with teacher reports of behavior. There was a weaker but significant relationship with other measures of sensory-motor performance and math skills on the WRAT-3. There were also fair to moderate relationships between five of the seven SSP sections and the SIB-R ($r = .33$ to $.63$), with the exception of the Taste/Smell and Movement Sensitivity subtests. This suggests that the SSP is measuring a unique construct that has some relevance to other educational and developmental domains as purported by SI theory.

The performance based sensory-motor measures (e.g. NEPSY, BOTMP) had stronger, moderate relationships with each other, as well as with the adaptive behavior and academic measures. This suggests there were some similarities in the domains measured by each of the sensory-motor tools, as well as a moderate relationship between sensory-motor performance, and adaptive behavior and academic skills. Of all the academic measures, fair to moderate relationships ($r = .33$ to $.72$) were seen most consistently with the WRAT-3 Math scale. The relationship between visuospatial processing and early math skills was particularly strong ($r = .72$). In contrast, findings from this study did not indicate that there were significant relationships between sensory-motor measures and teacher ratings of students' social skills, problem behaviors or academic competence in the classroom. The performance-based sensory-motor measures, clearly, had stronger relationships to academic skills than the SSP, whereas all of the sensory-motor measures had consistently moderate relationships with adaptive behavior.

The general statistical findings, therefore, suggested moderate relationships among several sensory-motor variables and measures of adaptive behavior and specific academic skills. Further examination of the results across the primary variables included in this study indicated that sensory-motor performance deficits did not occur in isolation in children with alcohol-related diagnoses; they also demonstrated significantly different performance on behavioral and academic measures. Such findings suggest that foundational sensory-motor abilities are at least in part related to other neurobehavioral difficulties and may lend some explanation to challenging behaviors as they interfere with higher level adaptive behavior, learning and social-emotional function (Ayres, 1972, 1979; Dunn, 1997; Parham & Mailloux, 2000; Wilbarger & Wilbarger, 1991, 2001).

Recent scholars have attempted to further clarify and define subtypes of DSI (Miller et al., 2000; Mulligan, 1996). Although it was not the intent of this study to classify children by these specific subtypes, children with alcohol–related diagnoses appeared to demonstrate more symptoms associated with poor sensory modulation. Both hyporesponsive and hyperresponsive behaviors and inconsistent responses to sensory input were reported, therefore, a tendency for these children to display fluctuating sensory responsivity. There was less evidence to suggest that children presented with symptoms of dyspraxia (i.e. motor planning problems), however, this construct was not comprehensively measured in this study. More research needs to be conducted with a broader range of measures, before additional conclusions are drawn regarding specific subtypes of DSI in this population, as well as other populations of children with disabilities.

Finally, the overall interpretation of these results within the context of SI theory deserves a cautionary note. It could be argued that the measures of sensory and motor functions selected to represent the construct of sensory integration in this study were somewhat fragmented, which would to some degree, compromise the theoretical application of these findings. While each measure was carefully chosen for both theoretical relevance and clinical feasibility as stated in the literature review, the use of a collection of tools rather than a comprehensive measure uniformly grounded in SI theory [e.g. Sensory Integration and Praxis Test (SIPT) (Ayres, 1989)] does limit specific contributions to theory development. It also speaks to the need for the development assessment tools that measure SI functions and are appropriate for children with a range of abilities.

Diagnostic Considerations

The diagnostic system for alcohol-related diagnoses used in this study provided a systematic method to identify and describe the continuum of diagnostic characteristics of children with histories of prenatal alcohol exposure (Astley & Clarren, 1999). Analysis of selected characteristics help to provide further understanding of the numerous developmental and environmental risk factors frequently associated with this population of children (Institute of Medicine, 1996). All but one child with an alcohol-related diagnosis presented with a history of other prenatal risk factors (e.g. exposure to other drugs, mother had no prenatal care) and more than three-quarters of the children also experienced moderate to high-risk postnatal factors (e.g. abuse, neglect, multiple home placements). Although all children with alcohol-related diagnoses had confirmatory evidence of prenatal alcohol exposure, the collective and potentially negative impact of these additional risk factors on development cannot be undermined, particularly when hypothesizing about the etiology of neurobehavioral differences.

There was also significant difference between the family structures of the groups of children in this study. Only eight percent of the children with alcohol-related diagnoses were in the care of a biological parent, while most children were in foster or adoptive homes. Despite this striking difference in family structure, children in the alcohol-exposed group were all in stable placements, which should have minimized the potential impact of current environmental risk factors and/or family instability on performance and behavior.

Alcohol-related diagnoses have also been considered a "hidden disability'. Consistent with other reports in the literature most of the children in this sample did not present with what could be considered "visible" physical indicators of prenatal alcohol exposure. Only one-quarter of the children with alcohol-related diagnoses had severe expression of the facial features or evidence of growth deficiency and only three children were diagnosed with the full Fetal Alcohol Syndrome. Furthermore, it was not uncommon for many children with alcohol-related diagnoses to perform within an average to low-average range on several measures in this study. Yet, an indication of neurobehavioral differences in this group of children, as reported in other studies, was evident in comparison to typically developing peers (Mattson & Riley, 1998).

Finally, one unique aspect of the four-digit diagnostic code is its ability to rank the magnitude of expression of specific diagnostic features (Astley & Clarren, 1999). The brain category is the most interesting from a clinical and educational perspective as it describes the level of CNS dysfunction based on multidisciplinary assessment. In this study, 32% of the children with alcohol-related diagnoses had a brain code 4, or evidence of structural brain abnormalities (e.g. microcephaly). For exploratory purposes, the test results of the children with alcohol-related diagnoses were separated into two groups based on their 4-digit diagnostic code brain rank. Although a formal analysis of group differences was not feasible due the small number of children per group and the risk of statistical violations, inspection of mean scores indicated some interesting trends.

On several measures, the mean scores shifted towards a level of poorer performance as the level of CNS dysfunction increased. For example, the TONI-2 scores by group were as follows: children with typical development (M = 109), brain code 2 (M = 95), and brain code 4 (M = 80); the mean scores of the SIB-R Broad Independence scale were (M = 107, 84, 61) respectively. Such findings indicate not only decreasing levels of function, but also highlight previously reported disparities between IQ and adaptive behavior in children with prenatal alcohol exposure (Streissguth et al., 1996). Children with typical development clearly had scores that suggested adaptive skills commensurate with their IQ level. In contrast, the group of children with alcohol-related diagnoses, brain code 4 in particular, presented with a gap greater than one standard deviation below the mean with skills in a very concerning range.

A similar trend was noted for the following measures of sensory-motor performance: the BOTMP, NEPSY and QNST-II, and WRAT-3, which suggests that a subgroup of children with CNS dysfunction (i.e. those with a brain code 4) also had lower levels of motor function. However, an opposite trend was seen for the SSRS Problem Behavior Scales. The highest mean scores were noted for the group with Brain Code 2. Thus, children with a brain code 2, (more "subtle" CNS dysfunction with no evidence of structural brain differences) showed higher rates of teacher reported behavior problems in comparison to children with a brain code 4 and children with typical development.

Although the generalization of these findings is limited, this information provides interesting prospective directions for future research. More systematic investigation of these trends with larger samples and appropriate statistical analysis may highlight important diagnostic information relative to neurobehavioral functions in children with alcohol-related diagnoses.

Educational Implications

Results from this study have several implications for educators that support directives from U.S. Department of Education to improve best practices, academic interventions and school-related outcomes for children with prenatal alcohol-exposure (U.S. Dept of Education, 2000). The most relevant findings for educators include: (a) the high rates of behavioral difficulties (e.g. more behavior problems and fewer adaptive behaviors) consistently reported by caregivers and educators, (b) decreased math abilities, (c) deficits in sensory processing and sensory-motor performance, (d) developmental profiles that included multiple prenatal and postnatal risk factors and differences in family structure, and (e) general performance in the low-average range across various neurobehavioral measures.

One of the most concerning findings of this study was the high frequency of behavior problems reported by both teachers and caregivers in comparison to same-aged peers. Given the other findings from this study, these behavioral difficulties could in part, be manifestations of sensory processing differences and/or subtle or emerging learning difficulties. For example, inattention or distractibility could presumably be a consequence of poor sensory modulation in response to a classroom environment with high amounts of auditory and visual stimulation. Likewise, negative classroom behaviors or noncompliance may be a result of increasing expectations in math or writing that exceed the visual motor abilities of the child.

In light of these issues, educators, school psychologists and other related services personnel should understand of the benefits of comprehensive, multidisciplinary assessments with this population of children. Such assessments may help examine and describe the often subtle, and potentially complex neurobehavioral deficits that may underlie behavior problems and contribute to learning difficulties. Given the high incidence of sensory processing difficulties as well as other sensory-motor deficits in this study, occupational therapist would be important members of this assessment team. Results from this study also suggest that children with alcohol-related diagnoses may need more support in math, as well as activities that require visual-motor precision and fine motor skills, such as learning how to print or write. As previously stated, early recognition, understanding and directed interventions may have important implications for decreasing the occurrence of secondary disabilities and improving developmental outcomes (Streissguth et al., 1996; Streissguth, 1997).

Special education services also appear to be an important support for children with alcohol-related diagnoses. Interestingly, despite poorer performance when compared to matched peers, the mean scores for the children with alcohol-related diagnoses on the majority of measures were "within normal limits" by most educational standards. Only, 20% to 52% of the children scored below one standard deviation from the mean on selected measures, and a mere 8% to 32% of children scored below two standard deviations from the mean. Yet, 64% of the children in this sample were receiving special education services.

Although details of the children's educational programs were not accounted for in this study, based on these scores, many children would not meet the criteria to qualify for special education services to support these areas of their learning and development. It could be speculated that factors such as an early diagnosis, broader eligibility criteria for children 8 years of age and younger, or mild delays across multiple developmental domains contributed to the relatively high rates of special education eligibility in this sample of children. Table 16 highlights the percent of children scoring below one and two standard deviations from the mean on selected variables.

Table 16

Percent of Children Scoring below 1 SD to 2 SD on Selected Variables

	Alcohol-Related Diagnoses		Typical Development	
Variable	% < 1 *SD*	% < 2 *SD*	% < 1 *SD*	% < 2 *SD*
BOTMP	24	16	4	0
NEPSY SM	20	8	8	0
NEPSY VP	52	24	8	0
TONI-II	24	8	4	0
SIB-R BI	48	32	4	0
WRAT-3 Read	32	12	8	0
WRAT-3 Spell	48	16	8	0
WRAT-3 Math	48	32	4	0

Relative to occupational therapy practices in educational settings, these findings suggest that occupational therapy assessment practices for children with alcohol-related diagnoses should include specific attention to sensory processing, visual-motor abilities, and qualitative aspects of motor performance. Behavioral and psychosocial needs are also important to consider and should be integrated into comprehensive assessment and intervention plans. Findings from this study also lend preliminary support for the use of a sensory integration framework to address the sensory-motor and related needs of young children with alcohol-related diagnoses. According to Sloan (2000) many therapists are already using a SI framework, despite noted limitations and the need for ongoing research to validate the efficacy of interventions (Mulligan, 2002; Polatajko et al., 1992).

Strengths and Limitations

Findings from this study need to be interpreted within the context of the study limitations. First, there may be bias in the sample of convenience for the group of children with alcohol-related diagnoses as well as the group of typically developing children. However, a relative strength with this same sample of children is the use of a group of children with alcohol exposure who were systematically diagnosed. The presence of confounding variables such as socioeconomic status, environment, and participation in occupational and physical therapy services or special education programs may also contribute to variations in test results. One of the most significant flaws of this study was the fact the SES was not accounted for. Other studies have indicated that this factor, in addition to variables such as maternal level of education, can significantly impact developmental outcomes (Bagheri et al., 1998; Coles, 1991; Larrouque et al., 1995).

The young age of the children in the study may have also impacted test results. In general, there is a high degree of developmental variation among 5 to 8 year old children. Designing the study with a comparison group of typically developing children was one method that was employed to minimize the potential impact of normal developmental variation and different rates of neuromaturation on test results. As noted, despite group differences, there were still children in the group with typical development who scored in a concerning range on some measures. There were also unexpected differences in the children's school programs that could have impacted results, particularly on the academic and school performance measures. Seven (28%) of the children with alcohol-related diagnosis were enrolled in preschool programs, whereas all of the five-year-old children in the comparison group were enrolled in kindergarten. Five-year old children are also at the lowest end of the normative sample on several tests selected for this study, including the WRAT-3, TONI-2 and QNST-II. Therefore, a valid basal level may not have been detected for some children.

The technical weaknesses of some of the evaluation tools are also a potential limitation of this study. The Short Sensory Profile and QNST-II, in particular, have some psychometric limitations, including the potential over identification of children with "typical" development. (e.g. 28% to 30% of the children with typical development had concerning scores on these two measures, as opposed to 4% to 8% of children on the other primary variables). The SSP, however, is the only standardized parent report measure of sensory processing and integration that is currently available in a published version. The QNST-II is one of the few standardized measures of neurological soft signs that can be administered and scored systematically. The use of a comparison group of typically developing children also addressed this caveat, and despite the concerning number of children with typical development identified, there were still significant differences between groups.

There may also be potential problems with the reliability of both performance-based tests and parent report measures. Performance based tests of young children may be impacted by factors such as fatigue, attention, or behavior problems. These issues must be considered in the interpretation of test results. Fortunately, all of the children enrolled were able to complete the tests and only two children in the alcohol-related diagnoses group required an additional test session. Although none of the data were eliminated due to questionable performance of the child, no formal procedures were established for the examiners to indicate the reliability of the test results. Such a procedure would be important to consider in future research studies.

The inconsistent test environment could also be considered a study limitation. The children were tested at a university clinic, school, or their home based on what was most comfortable and convenient for the parent. While testing all children in the same environment could have eliminated bias related to this factor, it may have negatively impacted study enrollment due to the geographic distribution of the participants and their families.

Since performance-based tests depict a limited sample of the child's level of function, parent and teacher reports were also used to evaluate several of the developmental domains in this study. Although a parent or teacher questionnaire may be a more comprehensive and reliable measure of behavior and daily functioning in young children over time, it is also subject to reporting bias. Including performance-based measures as well as parent and teacher reports was an effort to account for these factors as well as the notion that children perform differently across different physical and social environments.

Finally, as previously mentioned, the children in the comparison group were not formally screened for prenatal alcohol exposure. Thus, there was a potential risk of prenatal alcohol exposure in this group. However, any level of exposure was likely to be equivalent to that expected in the general population and was not expected to significantly influence test results. Asking self-report questions about alcohol exposure in an unsuspecting population also carries many ethical issues that need sufficient time and planned responses to be handled appropriately. It was felt that these issues in the comparison group were beyond the scope of this study and could not be sufficiently addressed.

Directions for Future Research

This exploratory study clearly indicates the need for more research to further validate sensory processing and integration difficulties in children with alcohol-related diagnoses. Replication and expansion of these results with other measures of sensory processing and sensory integration functions and larger sample sizes could increase the generalization and provide more support for these findings, particularly when one considers the percent of children with typical development who also demonstrated concerning scores on the SSP. Given the high rate of suspect findings in the group of children with typical development it is crucial to include a comparison group in such studies. Following the guidance of McIntosh et al. (1999) and Miller et al. (1999) it would also be advantageous to examine the physiological responses to different types of sensory stimuli in children with alcohol-related diagnoses.

Future research should also compare children with alcohol-related diagnosis with children with other disabilities to determine if the characteristics and findings described in this study are unique to children with alcohol-related diagnoses. Unique sensory processing profiles have been described for children with ADHD, autism and sensory modulation disorder (Dunn, 1999; Ermer & Dunn, 1997). The exploration of sensory-motor and other related variable based on selected diagnostic characteristics (e.g. brain, level of alcohol exposure, postnatal risk factors, etc.) of children with alcohol exposure with a larger sample would also be interesting and valuable from both a clinical and diagnostic perspective.

Given the reports of early regulatory difficulties and sensitivity to environmental stimuli (Eyler & Behnke, 1999), it would be important to pursue exploration of sensory processing and integration issues in infants and young children with prenatal alcohol exposure. Likewise, it would be useful to determine if sensory processing and integration profiles change as the children with alcohol-related diagnoses develop into late childhood and adolescence, particularly since developmental or maturation related effects were noted with some sensory-motor constructs explored in this study. In addition, teacher reports of responses to sensory stimuli in the classroom and subsequent comparisons between parent and teacher observations may provide more insight regarding the impact of different environments on sensory processing.

Finally, since two-thirds of the children in this study were receiving special education services it would also be important to find out more about the types of services that children with alcohol-related diagnoses are receiving in their educational programs. Since "qualifying' for services is often reported as difficult (Olson et al., 1998) it would be prudent to find out what special education categories children are being served under (e.g. behavior disorder, health impairment, etc.), as well as specific areas of focus on children's individualized educational programs (IEPs). Such research could contribute to improved interventions and academic outcomes.

Conclusion

This study examined a group of 5 to 8-year-old children who were systematically diagnosed with FAS and other alcohol-related conditions in comparison to a matched peer group on multiple neurobehavioral measures. Unlike previous research with this population, this study emphasized and examined a broader range of sensory and motor abilities from a distinctive and evolving theoretical framework commonly used by pediatric occupational therapists. Results from this study specifically document sensory processing and integration deficits in children with alcohol-related diagnoses, based on poorer performance across a number of sensory processing, sensory-motor and motor variables in comparison to peers with typical development.

Findings from the academic and behavioral measures in this study are consistent with the existing literature that describes a wide range of neurobehavioral difficulties in children with prenatal alcohol exposure (Mattson & Riley, 1998). Specifically, decreased math abilities, fewer adaptive behavioral skills and more teacher and caregiver reports of behavior problems were also found in this sample of children with alcohol-related diagnoses. In addition, common demographic characteristics of the children with alcohol-related diagnoses in this sample included high rates of prenatal and postnatal developmental risk factors (in addition to prenatal alcohol exposure), an alcohol-related diagnosis other than FAS, and current caregivers that were other than a biological parent.

This study also sought to explore the relationships between sensory processing and integration and selected academic and behavioral variables to further validate the use of a sensory integrative framework to understand neurobehavioral functions. Moderate relationships were seen between sensory and motor variables, adaptive behavior and math skills. Less conclusive relationships were seen between sensory-motor variables and teacher-reported classroom performance. Deficits in sensory processing and integration also co-occurred with other behavioral and academic difficulties. Finally, these measures were found to accurately classify a high percentage of children into groups based on the characteristic of an alcohol-related diagnosis or typical development.

Given the results from this study as well as previous findings, occupational therapist, educators and other related services providers need to consider the comprehensive needs of children with alcohol-related diagnoses, particularly in relation to special education services, the early and thorough identification of educational needs and improvement of academic outcomes. Future research that attempts to replicate these findings, and the subsequent exploration of educational and behavioral interventions for children with alcohol-related diagnoses based on an SI framework should be considered in light of efforts to mitigate the impact of prenatal alcohol exposure and other developmental risks in this population of children.

References

Aase, J. M., Jones, K. L., Clarren, S. K. (1995). Do we need the term "FAE"? Pediatrics, 95, 428-430.

Abel, E. L. & Sokol, R. J. (1987). Incidence of fetal alcohol syndrome and economic impact of FAS related anomalies. Drug and Alcohol Dependence, 19, 51-70.

Achenbach, T. & Edelbrock, C. (1986). Manual for the teacher's report form and teacher version of the Child Behavior Profile. Burlington, VT: University of Vermont, Department of Psychiatry.

Adnams, C. M., Kodituwakku, P. W., Hay, A., Molteno, C. D., Viljoen, D., May, P. A. (2001). Patterns of cognitive-motor development in children with fetal alcohol syndrome from a community in South Africa. Alcoholism: Clinical and Experimental Research 25 (4), 557-562.

American Occupational Therapy Association, (1987). Guidelines for occupational therapy in the school systems. Rockville, MD: American Occupational Therapy Association.

American Psychiatric Association, (1994). Category 315.40. Developmental Coordination Disorder: Diagnostic and statistical manual of mental disorders (4th ed. Revised). 53-55, Washington DC.

Ardilla, A., & Roselli, M. (1996). Soft neurologic signs in children: A normative study. Developmental Neuropsychology, 12, 181-200.

Astley, S. J. (2000). [Summary of first 1,000 patients evaluated: Washington State Diagnostic and Prevention Network]. (Unpublished raw data).

Astley, S. J., & Clarren, S. K. (1999). Diagnostic guide for fetal alcohol syndrome and related conditions (2nd ed.). Seattle, WA: University of Washington Publications.

Ayres, A. J. (1972). Sensory integration and learning disorders. Los Angeles: Western Psychological Services.

Ayres, A. J. (1979). Sensory integration and the child. Los Angeles: Western Psychological Services.

Ayres, A. J. (1989). Sensory Integration and Praxis Test manual . Los Angeles: Western Psychological Services.

Autti-Ramo, I., & Granstrom, M. L. (1991). The psychomotor development during the first year of life of infants exposed to intrauterine alcohol of various duration. Neuropediatrics, 22, 59-64.

Bagheri, M. M., Burd, L., Martsolf, J., & Klug, M. (1998). Fetal alcohol syndrome: Maternal and neonatal characteristics. Journal of Perinatal Medicine, 26, 263-269.

Baranak, G. T., Foster, L. G., & Berkson, G. (1997). Sensory defensiveness in persons with developmental disabilities. Occupational Therapy Journal of Research, 17(3), 173-85.

Barr, H. M., Streissguth, A. P., Darby, B. L., & Sampson, P. D. (1990). Prenatal exposure to alcohol, caffeine, tobacco, and aspirin: Effects on fine and gross motor performance in 4-year old children. Developmental Psychology, 26, 339-348.

Brown, L., Sherbenou, R. J., & Johnson, S. K. (1990). Test of Nonverbal Intelligence test manual (2nd ed.). Austin, TX: ProED.

Brown, R. T., Coles, C. D., Smith, I. E., Platzman, K. A., Silverstein, J., Erickson, S., & Falek, A. (1991). Effects of prenatal alcohol exposure at school age. II: Attention and behavior. Neurotoxicology and Teratology, 13, 369-376.

Bruininks, R. H. (1978). Bruininks-Oseretsky Test of Motor Proficiency test manual. Circle Pines, MN: American Guidance Service.

Bruininks, R. H., Woodcock, R. W., Weatherman, R. F., & Hill, B. K. (1996). Scales of Independent Behavior-Revised: Comprehensive manual. Chicago: Riverside Publishing.

Bundy, A. C., & Murray, E. A. (2002). Sensory integration: A. Jean Ayres' theory revisited. In A. C. Bundy, S. J. Lane, & E. A., Murray (Eds.), Sensory integration theory and practice (2nd ed.). (pp. 3-33). Philadelphia: F. A. Davis.

Bundy, A. C. (2002). Assessing sensory integrative dysfunction. In A. C. Bundy, S. J. Lane, & E. A., Murray (Eds.), Sensory integration theory and practice (2nd ed.). (pp. 169-198). Philadelphia: F. A. Davis.

Burgess, D. M., Lasswell, S. L., & Streissguth, A. P. (1992). Educating children prenatally exposed to alcohol and other drugs. Planning for Learning Project. Seattle, WA: FADU, University of Washington.

Burgess, D. M., & Streissguth, A. P. (1992). Fetal alcohol syndrome and fetal alcohol effects: Principles for educators. Phi Delta Kappen, 74 (1) 24-30.

Chandler, L. S., Richardson, G. A., Gallagher, J. D., & Day, N. L. (1996). Prenatal exposure to alcohol and marijuana: Effects on motor development of preschool children. Alcoholism: Clinical and Experimental Research, 20(3), 455-461.

Church, M. W., Klattenbach, J. A. (1997). Hearing, speech, vestibular, and dentofacial disorders in fetal alcohol syndrome: A literature review. Alcoholism: Clinical and Experimental Research, 21, 495-512.

Clarren, S. K., & Smith, D. W. (1978). The fetal alcohol syndrome. The New England Journal of Medicine, 298, 1063-1067.

Clark, C. M., Li, D., Conry, J., Conry, R., Loock, C. (2000). Structural and functional brain integrity of fetal alcohol syndrome in nonretarded cases. Pediatrics, 105, 1096-1099.

Coggins, T. E., Friet, T., & Morgan, T. (1998). Analyzing narrative productions in older school-age children and adolescents with fetal alcohol syndrome: An experimental tool for clinical applications. Clinical and Linguistic Phonetics, 12(3), 221-236.

Coles, C. D., Brown, R. T., Smith, I. E., Platzman, K. A., Erickson, S., & Falek, A. (1991). Effects of prenatal alcohol exposure at school-age. I. Physical and cognitive development. Neurotoxicology and Teratology, 13, 357-367.

Coles, C. D., Platzman, K. A., Raskind-Hood, C. L., Brown, R. T., Falek, A., & Smith, I. E. (1997). A comparison of children affected by prenatal alcohol exposure and attention deficit hyperactivity disorder. Alcoholism: Clinical and Experimental Research, 21(1), 150-161.

Connor, P. D., & Streissguth, A. P. (1996). Life stage issue: Effects of prenatal exposure to alcohol across the lifespan. Alcohol and Research World, 20(3), 170-174.

Dahl-Reeves, G. & Cermak, S. A. (2002). Disorders of praxis. In A. C. Bundy, S. J. Lane, & E. A., Murray (Eds.), Sensory integration theory and practice (2nd ed.). (pp. 71-100), Philadelphia: F. A. Davis.

Dunn, W. (1999). Sensory Profile manual. San Antonio, TX: Psychological Corporation.

Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. Infants and Young Children, 9(4), 23-35.

Ermer, J. & Dunn, W. (1998). The sensory profile: A discriminant analysis of children with and without disabilities. American Journal of Occupational Therapy, 52(4), 283-290.

Eyler, F. D. & Behnke, M. (1999). Early development of infants exposed to drugs prenatally. Clinics in Perinatology, 26(1), 107-150.

Finlayson, S. B. & Obrrzut, J. E. (1993). Factorial structure of the Quick Neurological Screen Test-revised, for children with learning disabilities. Psychology in the Schools, 30, 5-10.

Fried, P. A. & Watkinson, B. (1990). 36- and 48-month neurobehavioral follow-up of children parentally exposed to marijuana, cigarettes and alcohol. Journal of Developmental and Behavioral Pediatrics, 11, 49-58.

Fulks, M., & Harris, S. (1995). Children exposed to drugs in utero: Their scores on the Miller Assessment for Preschoolers. Canadian Journal of Occupational Therapy. 62(1), 7-15.

Greene, T., Ernhart, C. B., Ager, J., Sokol, R., Martier, S., & Boyd, T. (1991). Prenatal alcohol exposure and cognitive development in the preschool years. Neurotoxicology and Teratology, 13(1), 57-68..

Gresham, F. M. & Elliot, S. N. (1990). The Social Skills Rating System manual. Circle Pines, MN: American Guidance Service.

Guerri, C. (1998). Neuroanatomical and neurophysiological mechanisms involved in central nervous system dysfunction induced by prenatal alcohol exposure. Alcoholism: Clinical and Experimental Research, 22(2), 304-312.

Giuffrida, C. (2001). Praxis, motor planning, and motor learning. In S. Smith Roley, E. I. Blanche, & R. C. Schaaf, (Eds.). Understanding the nature of sensory integration with diverse populations (pp. 133-182). San Antonio, TX: Therapy Skill Builders.

Hanft, B. E., Miller, L. J., & Lane, S. J., (2000). Toward a consensus in terminology in sensory integration theory and practice: Part three: Observable behaviors: sensory integration dysfunction. Sensory Integration Special Interest Section Quarterly, 23(2), 1-4.

Harris, S. R., Osborn, J. A., Weinberg, J., Loock, C., & Junald, K. (1993). Effects of prenatal alcohol exposure on neuromotor and cognitive development during early childhood: A series of case reports. Physical Therapy, 73(9), 608-617.

Harter, S. (1985). Manual for the self-perception profile for children. University of Colorado: Denver, CO.

Individual with Disabilities Education Act, 1997 Amendments. 20 U.S.C. 1400 et seq.

Institute of Medicine. Division of Biobehavioral Sciences and Mental Disorders. (1996). Fetal alcohol syndrome: Diagnosis, epidemiology, prevention and treatment. Washington DC: National Academy Press.

Interagency Coordinating Committee on Fetal Alcohol Syndrome. (2000). Early Childhood Neurobehavioral Assessment for the Differential Diagnosis of Fetal Alcohol Syndrome and Alcohol Related Neurodevelopmental Disorder. Bethesda, MD.

Jacobsen, J. L., Jacobsen, S. W., Sokol, R. J., Martier, S. S., Ager, J. W., Kaplan Estrin, M. G. (1993). Teratogenic effects of alcohol on infant development. Alcoholism: Clinical and Experimental Research, 17(1); 174-183.

Janzen, L. A., Nanson, J. L. & Block, G. W. (1995). Neuropsychological evaluation of preschoolers with fetal alcohol syndrome. Neurotoxicology and Teratology, 17(3), 273-279.

Jirikowic, T. [Washington State Diagnostic and Prevention Network]. (Unpublished raw data).

Johnson-Ecker C. L., & Parham, L. D. (2000). The evaluation of sensory processing: A validity study using contrasting groups. American Journal of Occupational Therapy, 54(5), 494-503.

Jones, K. L., & Smith, D.W. (1973). Recognition of the fetal alcohol syndrome in early infancy. Lancet, 2, 999-1001.

Jones, K. L., & Smith, D.W., Ulleland, C. N., & Streissguth, A. P. (1973). Patterns of malformation in offspring of chronic alcoholic mothers. Lancet, 1, 1267-1271.

Kaufman, A. S. & Kaufman, N. L. (1983). Kaufman Assessment Battery for Children Interpretive Manual. Circle Pines, MN: American Guidance Service.

Kimball, J. G. (1999). Sensory integration frame of reference: Theoretical base, function/dysfunction continua and guide to evaluation. In P. Kramer & J. Hinojosa, (Eds.), Frames of reference for pediatric occupational therapy (2nd ed.). (pp. 119-168), Baltimore, MD: Lippincott, Williams, and Wilkins.

Kleinfeld, J., & Wescott, S. (Eds.). (1993). Fantastic Antoine succeeds: Experiences in educating children with fetal alcohol syndrome. Fairbanks, AK: University. of Alaska Press.

Kleinfeld, J., Morse, B., & Wescott, S. (Ed.) (2000). Fantastic Antoine grows up: Adolescents and adults with fetal alcohol syndrome. Fairbanks, AK: University of Alaska Press.

Kyllerman, M., Aronson, M., Sabel, K. G., Karlberg, E., Sandin, B., & Olegard, R. (1985). Children of alcoholic mothers: Growth and motor performance compared to matched controls. Acta Paediatrica Scandinavia, 74, 20-26.

Korkman, M., Kirk, U., & Kemp, S. (1998). NEPSY: A developmental neuropsychological assessment. Test Manual. San Antonio, TX: The Psychological Corporation.

Landon, E. (1978). Early screening for LD: A correlational study of Bender Gestalt and Quick Neurological Screening Test. Unpublished Master's thesis, San Jose State University, San Jose, CA.

Lane, S. J., Miller, L. J., & Hanft, B. E. (2000, June). Toward a consensus in terminology in sensory integration theory and practice: Part Two: Sensory integration patterns of function and dysfunction. Sensory Integration Special Interest Section Quarterly, 23(2), 1-4.

Larrouque, B., & Kaminski, M., Dehaune, P., Subtil, D., Delfosse, M., & Querleu, D. (1995). Moderate prenatal alcohol exposure and psychomotor development at preschool age. American Journal of Public Health, 85, 1654-1661.

Larrouque, B., & Kaminski, M. (1998). Prenatal alcohol exposure and development at preschool age: main results from a French study. Alcoholism: Clinical and Experimental Research, 22(2), 295-303.

Mailloux, Z. (1997, September). Sensory integration and role performance in students. . Sensory Integration Special Interest Section Quarterly, 20(3), 1-2.

Marcus, J. C. (1987). Neurological findings in the fetal alcohol syndrome. Neuropediatrics, 18, 158-160.

Mattson, S. N., Riley, E. P., Gramling, L., Delis, D. C., & Jones, K. L. (1998). Neuropsychological comparison of alcohol exposed children with or without the physical features of fetal alcohol syndrome. Neuropsychology, 12(1), 16-153.

Mattson, S. J., & Riley, E. P. (1998). A review of the neurobehavioral deficits in children with fetal alcohol syndrome or prenatal alcohol exposure. Alcoholism: Clinical and Experimental Research, 22(2), 279-294.

McIntosh, D. N. Miller, L. J., Shyu, V., Dunn, W. (1999). In Sensory Profile test manual, (pp. 59-73). San Antonio, TX: Psychological Corporation.

McIntosh, D. N., Miller, L. J., Shyu, V., & Hagerman, R. J. (1999). Sensory modulation disruption, electrodermal responses, and functional behaviors. Developmental Medicine and Child Neurology, 41, 608-615.

Miller, L. J. (1988). Miller Assessment for Preschoolers manual. San Antonio, TX: Psychological Corporation.

Miller, L. J., Lane, S.J. & Hanft, B. (2000, March). Toward a consensus in terminology in sensory integration theory and practice: Part one: Taxonomy of neurophysiological process. Sensory Integration Special Interest Section Quarterly 23(1), 1-4.

Miller, L. J., McIntosh, D. N., McGrath, J., Shyu, V., Lampe, M., Taylor, A. K., et al. (1999). Electrodermal responses to sensory stimuli in individuals with Fragile X syndrome: A preliminary report. American Journal of Medical Genetics, 83, 268-279.

Missiuna, C., & Polatajko, H. (1995). Developmental dyspraxia by any other name. Are they just clumsy children? American Journal of Occupational Therapy, 49, 619-627.

Morse, B. A. & Weiner, L. (1996). Rehabilitation approaches for fetal alcohol syndrome. In H. L. Spohr & H. C. Steinhausen (Eds.), Alcohol, pregnancy and the developing child (pp. 249-268). New York: NY Cambridge.

Morse, B. A., Miller, P. T., & Cermak, S. A. (1995). Sensory processing in children with FAS. Alcoholism: Clinical and Experimental Research, 18, 503(abstr).

Mulligan, S. (1996). An analysis of score patterns of children with attention disorders on the Sensory Integration and Praxis Tests. American Journal of Occupational Therapy, 50(8), 647-654.

Mulligan, S. (1998). Patterns of sensory integrative dysfunction: A confirmatory factor analysis. American Journal of Occupational Therapy, 52(10), 819-828.

Mulligan, S. (2002) Advances in sensory integration research. In A. C. Bundy, S. J. Lane, & E. A., Murray (Eds.), Sensory integration theory and practice (2nd ed.). (pp. 397-412), Philadelphia: F. A. Davis.

Mutti, M. A., Sterling, M. D., Martin, N. A., & Spalding, N. V. (1998). Quick Neurological Screening Test-II. Novato, California: Academic Therapy Publications

Nanson, J. L., & Hiscock, M. (1990). Attention deficits in children exposed to alcohol prenatally. Alcoholism: Clinical and Experimental Research, 14(5), 656-661.

Olson, H. C., Sampson, P. D., Barr, H. Streissguth, A. P., & Bookstein, F. L. (1992). Prenatal exposure to alcohol and school problems in late childhood: A longitudinal prospective study. Development and Psychopathology, 4, 341-359.

Olson, H. C. (1994). The effects of prenatal alcohol exposure on child development. Infants and Young Children, 6(3), 10-25.

Olson, H. C., Morse, B., & Huffine, C. (1998). Development and psychopathology: Fetal alcohol syndrome and related conditions. Seminars in Clinical Neuropsychiatry, 3(4), 262-284.

Osborn, J. A., Harris, S. R., Weinberg, J. (1993). Fetal alcohol syndrome: Review of the literature with implications for physical therapists. Physical Therapy, 73(9), 599-607.

Osher, D., & Hanley, T. V. (1996). Implications of the national agenda to improve results for children and youth with or at risk of serious emotional disturbance. Special Services in the Schools, 10(2), 7-36.

Parham, L. D. (1998). The relationship of sensory integrative development to achievement in elementary students: Four-year longitudinal patterns. Occupational Therapy Journal of Research, 18(3), 105-127.

Parham, L. D., & Mailloux, Z. (2001). Sensory integration. In J. Case-Smith, A. S. Allen and P. N. Pratt (Eds.), Occupational therapy for children. (4th ed.) St. Louis: Mosby.

Polatajko, H., Kaplan, B. J. & Wilson, B. N. (1992). Sensory integration treatment for children with learning disabilities: Its status 20 years later. Occupational Therapy Journal of Research, 12(6), 323-341.

Portney, L. G., & Watkins, M. P. (2000). Foundations of clinical research applications to practice, (2nd ed.), Upper Saddle River, NJ: Prentice Hall Health

Richardson, G. A., & Day, N. (1991). Prenatal exposure to alcohol, marijuana, and tobacco: Effect on infant mental and motor development. Abstract: Society for Research on Childhood Development, 8, 421

Roebuck, T. M., Mattson, S. N., & Riley, E. P. (1998). A review of the neuroanatomical findings in children with fetal alcohol syndrome or prenatal exposure to alcohol. Alcoholism Clinical and Experimental Research, 22(2), 339-344.

Roebuck, T. M., Simmons, R.W., Richardson, C. R., Mattson, S., & Riley, E. P. (1998). Neuromuscular response to disturbances of balance in children with prenatal alcohol exposure. Alcoholism: Clinical and Experimental Research, 22(9), 1992-1997.

Roebuck, T. M., Simmons, R. W., Mattson, S. N., & Riley, E. P. (1998). Prenatal exposure to alcohol affects the ability to maintain postural balance. Alcoholism: Clinical and Experimental Research, 22(1), 252-258.

Roebuck, Mattson, S., & Riley, E. P. (1999). Behavioral and psychosocial profiles of alcohol-exposed children. Alcoholism: Clinical and Experimental Research, 23(6), 1070-1076.

Sarracino, T. (1997, September). Applying a sensory integrative frame of reference in school practice. Sensory Integration Special Interest Section Quarterly, 20(3), 1-2.

Sloan, K. (2000). Occupational therapy and fetal alcohol syndrome: A survey of therapist's knowledge and practices. Unpublished masters thesis. University of Puget Sound, Tacoma, WA.

Spitzer & Smith Roley, S, (2001). Sensory integration revisited: A philosophy of practice. In S. Smith Roley, E. I. Blanche, & R. C. Schaaf, (Eds.). Understanding the nature of sensory integration with diverse populations (pp. 3-28). San Antonio, TX: Therapy Skill Builders.

Spohr, H. L. & Steinhausen, H. C. (Eds.) (1996). Alcohol, pregnancy and the developing child. New York: NY Cambridge.

Spreen, O., Rissser, A. H., & Edgell, D. (1995). Soft neurological signs and their significance. Developmental Neuropsychology. (pp. 347-362). New York: Oxford University Press.

Stephan, J. (1978). Correlational study of the QNST, WRAT, and PIAT. Unpublished masters thesis. San Jose State University: San Jose, CA.

Stephens, T. (1981). Technical manual: Social Behavior Assessment. Columbus, OH: Cedars Press.

Streissguth, A., Barr, H., Kogan, J., & Bookstein, F. L. (1996). Understanding the occurrence of secondary disabilities in clients with fetal alcohol syndrome (FAS) and fetal alcohol effects (FAE). Seattle, WA: University of Washington Publications.

Streissguth, A., Barr, H. M., Sampson, P. D., & Bookstein, F. L. (1994). Prenatal alcohol and offspring development: The first fourteen years. Drug and Alcohol Dependence, 36, 89-99.

Streissguth, A. (1997). Fetal alcohol syndrome: A guide for families and communities. Baltimore, MD: Paul H. Brookes Publishing.

Streissguth, A. & Kanter, J. (1997). The challenge of fetal alcohol syndrome: Overcoming secondary disabilities. Seattle, WA: University of Washington Press

Streissguth, A. P., Sampson, P., & Barr, H. M. (1989). Neurobehavioral dose-response effects of prenatal alcohol exposure in humans from infancy to adulthood. Annals of the New York Academy of Sciences, 562, 145-158.

Thomas, S. E., Kelly, S. J., Mattson, S. N., & Riley, E. P. (1998). Comparison of social abilities of children with Fetal Alcohol Syndrome to those of children with similar IQ scores and normal controls. Alcoholism: Clinical and Experimental Research, 22(2), 528-533.

U.S. Department of Education (2000). Prenatal exposure to alcohol and nicotine: Implications for special education. Twenty-second annual report to congress on the implementation of the individuals with disabilities education act. Washington DC. pp. I-15-34.

Wentz, T. (1997). A national survey of state directors of special education concerning students with FAS. In A. Streissguth & J. Kanter (Eds.), The challenge of fetal alcohol syndrome: Overcoming secondary disabilities, Seattle, WA, University of Washington Press

Whaley, S. E., O'Connor, M. J. & Gunderson, B. (2001). Comparison of the adaptive functioning of children prenatally exposed to alcohol to a non-exposed clinical sample. Alcoholism: Clinical and Experimental Research, 25(7), 1018-1024.

Wilbarger, P. & Wilbarger, J. (1991). Sensory defensiveness in children ages 2-12: An intervention guide for parents and other caretakers. Santa Barbara, CA: Avanti Educational Programs.

Wilbarger, P. & Wilbarger, J. (2001). Sensory defensiveness: A comprehensive Treatment Approach. Denver, CO: Avanti Educational Programs

Wilkinson, G. S. (1993). Wide Range Achievement Test–3 manual. Wilmington, Delaware: Wide Range, Inc.

Windsor, M. M., Smith, R. S., & Sklut, S. (2001). Assessment of sensory integration and praxis. In S. Smith Roley, E. I. Blanche, & R. C. Schaaf (Eds.), Understanding the nature of sensory integration with diverse populations (pp. 215-246). San Antonio, TX: Therapy Skill Builders.

Appendix A 4-Digit Diagnostic Code

What are the 4 Digits?

The four digits reflect the magnitude of expression of the four key diagnostic features of FAS in the following order: (1) growth deficiency, (2) the FAS facial phenotype, (3) brain dysfunction, and (4) gestational alcohol exposure. The 4-Digit Diagnostic Code is generated at the completion of the diagnostic evaluation using information recorded on the FAS Diagnostic Evaluation Form. The code is derived following the directions in Sections III. B. 1 through B. 4.

4-Digit Diagnostic Code Grid

				3	4	4	4		
significant	Severe	definite	(4)		X	X	X	(4)	high risk
moderate	Moderate	probable	(3)	X				(3)	some risk
mild	Mild	possible	(2)					(2)	unknown
none	Absent	unlikely	(1)					(1)	no risk
Growth Deficiency	**FAS Facial Features**	**Brain Dysfunction**		Growth	Face	Brain	Alcohol		**Gestational Alcohol**

The 4-Digit Diagnostic Code 3444 inserted in the grid is one of twelve that qualifies as a diagnosis of FAS.

How are the 4 Digits ranked?
The magnitude of expression of each feature is ranked independently on a 4-point Likert scale with 1 reflecting complete absence of the FAS feature and 4 reflecting a strong "classic" presence of the FAS feature.

Reprinted with permission from Astley, S. J., & Clarren, S. K. (1999). Diagnostic guide for fetal alcohol syndrome and related conditions (2nd ed.). Seattle, WA: University of Washington Publication.

Appendix B Deriving the 4-Digit Diagnostic Code Rank for Brain Function

4-Digit Diagnostic Code Rank*	Brain Dysfunction Scale	Confirmatory Findings
4	**Definite** *referred to as static encephalopathy*	• Microcephaly, OFC ≤ -2 S. D. *and / or* • Abnormalities on brain images diagnostic of prenatal alteration *and / or* • Evidence of persistent neurologic findings likely to be of prenatal origin *and / or* • I. Q. score ≤ 60
3	**Probable** *referred to as static encephalopathy*	• Substantial deficiencies or discrepancies across multiple areas of brain performance such as cognition, achievement, adaptation, neurologic "soft" signs, and language. Generally three or more areas should be found aberrant.
2	**Possible** *referred to as neurobehavioral disorder*	• Historical information / personal observations strongly suggest the possibility of brain damage, but data to this point does not permit a Rank 3 or 4 classification.
1	**Absent**	• No problems likely to reflect brain damage are presented.

Reprinted with permission from: Astley, S. J., & Clarren, S. K. (1999). Diagnostic guide for fetal alcohol syndrome and related conditions (2nd ed.). Seattle, WA: University of Washington Publications.

Appendix C Deriving the 4-Digit Diagnostic Code Rank for Alcohol Exposure

4-Digit Diagnostic Code Rank*	Gestational Alcohol Exposure Category	Description
4	High Risk	• Alcohol use during pregnancy CONFIRMED *and* • Exposure pattern is consistent with the medical literature placing the fetus at "high risk" (generally high peak blood alcohol concentrations delivered at least weekly in early pregnancy).
3	Some Risk	• Alcohol use during pregnancy CONFIRMED *and* • Drinking occurred in gestation in frequencies and volumes less than in Rank (4) or exact amounts unknown.
2	Unknown Risk	• Gestational exposure is simply not known or information is of questionable reliability
1	No Risk	• Alcohol use during pregnancy is CONFIRMED to be completely ABSENT.

From: Astley, S. J., & Clarren, S. K. (1999). Diagnostic guide for fetal alcohol syndrome and related conditions (2nd ed.). Seattle, WA: University of Washington Publications.

Appendix D Letter of Recruitment: Alcohol-Related Diagnosis Group

Dear Parent/Caregiver,

I am an occupational therapist and a doctoral student at the University of Washington College of Education. I am doing a study on the sensory and motor (movement) abilities of young children, and how this relates to their day-to-day behavior, how they do in school, and how they interact with other children and adults. You and your child were selected as possible participants in this study because your child has attended the University of Washington Fetal Alcohol Syndrome Diagnostic Clinic.

Should you decide to participate, your child and a caregiver that knows him or her well will be scheduled for a 90-minute to 2-hour visit, depending on your preference at the University of Washington or your home. Your child will be given developmental tests to assess movement, sensory-motor skills and learning free of charge. You or another caregiver will also complete 2 checklists to tell us how the child responds to information from his or her senses (sight, sound, hearing, movement, etc.) and how he or she is manages daily tasks at home. Your child's teacher will also be asked complete a short checklist about how your child does in school.

By participating in this study, you will have the opportunity to learn about your child's learning and development. Results from this study may also help other parents, teachers, and professionals better recognize and understand some types of learning problems and difficult behaviors in young children with prenatal alcohol exposure.

Please return the stamped postcard response by _______ or call me at 206-526-2522, if you would like to participate in the study or would like more information. Thank you for your time. I am very excited to be working on this project and would be happy to answer any questions you may have. I look forward to hearing from you.

Sincerely,

Tracy Jirikowic, MS, OTR/L
Occupational Therapist

Post card response

______ No, I am not interested in participating in this study.
______ Yes, I am interested in participating in the study. Please contact me.

I can be reached at this number ___________. Best time to call ___________.
(Participant number _____)

Appendix E Telephone Script

Hello, May I speak with ________.

My name is Tracy Jirikowic. I sent you the letter about the research study. Thank you for returning it to me. Is this a good time to talk with you? (If no, I'd like to set up a time to talk with you for 10 to 15 minutes. What time would be convenient for you?)

I would like to tell you more about the study. The purpose of this study is to learn about the sensory and motor abilities of young children and how this relates to their learning and behavior at home and school.

Procedures

If you decide to participate, yourself or another caregivers that knows your child well, will be scheduled for a 90-minute to 2-hour visit at the University of Washington, your child's school or at your home for a test session. Your child will be given some developmental tests that examine movement, thinking, and early learning skills. Examples of the test activities include building with blocks, balancing, drawing with a pencil, and beginning tests of reading, spelling and math.

You or another caregiver will also be requested to fill out 2 checklists about your child's behavior. The first checklist will ask you to respond to how your child responds to movement, touch, and what he or she hears and sees. This checklist is being used to see if children have different responses to sensory information (i.e. what they see hear, feel smell, etc). The second checklist will ask questions about how well your child interacts with other children and adults, how your child is learning to eat, dress, and play, how well your child listens and talks with others, and how your child coordinates his hand and body movements.

All test items are presented playfully as games or learning activities similar to what a child would complete at school. There should be no significant risks or discomfort for you or your child, although your child may become bored or tired during the test. You or your child will be able to stop the testing at any time.

Are you still interested in participating?

I would like to schedule you and your child for the test session at your home, school (if in comparison group) or the University of Washington. What days and times would be most convenient for you and your child?

Do you have any additional questions?

Thank you for your time and interest. Please contact me at 206-526-2522 if you need to change the appointment.

Appendix F Consent Form: Alcohol-Related Diagnoses Group

UNIVERSITY OF WASHINGTON
CONSENT FORM
Sensory-Motor Development, Learning, and Behavior in Young Children

Researcher: Tracy Jirikowic, Registered Occupational Therapist
College of Education, Department of Special Education
Telephone: 206-526-2206

Researchers' statement
I am asking you and your child to be in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions, you can decide if you want to be in the study or not. This process is called 'informed consent.' We will give you a copy of this form for your records.

PURPOSE AND BENEFITS
This study is being done in partial fulfillment of the requirements for a Doctor of Philosophy degree at the University of Washington. The purpose of this study is to learn about the sensory and motor development of young children and how this relates to their learning and behavior at home and school. Understanding more about these areas of development may help parents, teachers, and other professionals understand some types of challenging behaviors and learning differences in young children. This may also help parents and professionals recognize, and get help for some of these problems early in a child's school program.

PROCEDURES
Should you and your child decide to participate, yourself or another caregiver that knows the child well, will be scheduled for a 90 minute to 2-hour visit at the University of Washington or your home. Your child will be given some developmental tests that look at movement, thinking, and early learning skills. Examples of the test activities include running, balancing, building with blocks, drawing with a pencil, and beginning tasks of reading, spelling and math.

You or another caregiver will also be requested to fill out 2 checklists about your child's behavior. The checklists will take about one hour to complete. The first checklist will ask you questions about how your child responds to movement, touch, and what he or she hears and sees. This checklist is being used to see if children have different responses to sensory information. The second checklist will ask questions about how your child interacts with other children and adults, how your child is learning to eat, dress, and play, how your child listens and talks with others, and how your child coordinates his hand and body movements.

After getting your permission, I will also ask your child's teacher to fill out a short checklist about how your child is learning in school and how he or she plays and gets along with classmates. This checklist will take about 15 minutes to complete.

RISKS, STRESS, OR DISCOMFORT

As a researcher I am required to tell you about any risks, stress or discomfort that may occur by participating in this study. Although all test items are presented playfully as games or learning activities just like your child would do at school, a child may become tired or frustrated during the test session. If this occurs, a break will be taken, or testing will be stopped. Your child may also understand that he or she is being given school related tasks and asked to do tasks that may be difficult, which may be stressful for him or her. Finally, some of the tests will require the test administrators to gently touch and/or move the child's hands, arms, or legs which may be uncomfortable for your child.

You may find out new information about your child's development and learning abilities. This information would include areas of development where your child is doing well, or possibly, areas of development that are more difficult. If you are interested, I can review test results with you after the test session by phone.

OTHER INFORMATION

You and your child's identity will be kept strictly confidential. All information from the testing will be stored with a code number instead of names in a locked file at the University of Washington. Names will never be made public. The final results of the study will be on file in the dissertation section of the University of Washington Library and may be published in a professional journal or presented at a professional meeting.

When your child was diagnosed in the FAS Clinic, his/her data was entered into the FAS Clinic database to help us provide you with ongoing clinical care. With your permission we would like to enter results from this study into this database so that we have the latest clinical information in your child's FAS Clinic record. This information would be helpful if your child is seen for follow-up care or consultation with the clinic. The data may also be used for research purposes. You will be asked to sign a separate research consent form (called the FAS DPN Research Participation Consent Form) to give us permission to do this. You are not required to let us enter your data into the FAS Clinic Database and use it for additional research.

The investigator will pay for any study-related parking expenses at the University of Washington. Your child will also receive a small educational book or toy for participating in this study.

As a volunteer for this study, you may refuse to answer any question or item in either of the questionnaires. You will be able to stop the testing with your child at any time. Your child will also be told that he or she can take a break or stop testing at any time. Your participation is totally voluntary and will not affect any regular services your child may currently receive. A copy of the consent form will also be placed in the your child's FAS-DPN records at the University of Washington.

____

Printed name of researcher   Signature of researcher   Date

Participant's statement

This study has been explained to me. I volunteer to take part in this research and give consent for my child to participate. I have had a chance to ask questions. If I have questions later about the research, I can ask one of the researchers listed above. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

____

Printed name of participant   Signature of parent/guardian   Date

Appendix G Follow-up Recruitment Letter

Dear Parent/Caregiver,

I am an occupational therapist and a doctoral student at the University of Washington College of Education. A few weeks ago I sent out a letter to see if you and your child were interested in participating in a research study. I would still like to invite you to participate and would be happy to tell you more about the study over the phone.

I am doing a study on the sensory and motor (movement) development of young children, and how this relates to daily behavior, how they do in school, and how they interact with other children and adults. This is a chance for you to learn more about your child's learning and development.

Should you decide to participate, your child and a caregiver that knows him or her well will be scheduled for a 90-minute to two-hour test session. Your child will be given developmental tests to assess movement, sensory-motor skills and early learning free of charge. Yourself or another caregiver will also be requested to complete 2 checklists to rate your child's behavior and skills, to tell us how your child is learning and doing at home and school. Your child's teacher will also need to complete a short checklist about how your child does in school.

Please return the enclosed postcard by ________ or call 206-526-2522 if you would like to participate in this study, or would like more information. Thank you for your time. I am very excited to be working on this project. It is an important study to help us better understand how young children learn and develop.

Sincerely,

Tracy Jirikowic, MS, OTR/L
Occupational Therapist

Post card response

______ No, I am not interested in participating in this study.

______ Yes, I am interested in participating in the study. Please contact me.

I can be reached at this number ___________. Best time to call ___________.

(Participant number _____)

Appendix H Letter of Recruitment: Comparison Group

Dear Parent/Caregiver,

I am an occupational therapist and a doctoral student at the University of Washington College of Education. I am doing a study on the sensory and motor (movement) abilities of young children, and how this relates to their daily behavior, how they do in school, and how they interact with other children and adults. You and your child were selected as possible participants in this study because your child attends a school that often works with the University of Washington College of Education on important educational matters that helps kids in school.

Should you decide to participate with your child, your child and a caregiver that knows him or her well will be scheduled for a 90 minute to 2 hour visit at the University of Washington, your home, or your child's school, depending on your preference. Your child will be given developmental tests on movement, sensory-motor skills and learning free of charge. You or another caregiver will also complete 2 checklists to tell us how he/she responds to information from his or her senses (sight, sound, hearing, movement, etc.) and how he/she is manages daily tasks at home. It will take about one hour to complete the checklists. Your child's teacher will also be asked to complete a short checklist about how your child is doing in school.

By participating in this study, you will have the opportunity to learn about your child's learning and development. Results from this study may also help other parents, teachers, and professionals understand learning and behavior differences in young children and identify some problems early in school.

Please return the enclosed postcard by ________ or call 206 526-2522 if would like to participate in this study with your child or if you would like more information. Thank you for your time. I am very excited to be working on this project and would be happy to answer any questions you may have. I look forward to hearing from you.

Sincerely,

Tracy Jirikowic, MS, OTR/L
Occupational Therapist

Post card response

______ No, I am not interested in participating in this study.
______ Yes, I am interested in participating in the study. Please contact me.

I can be reached at this number ___________. Best time to call ___________
(Participant number _____)

Appendix I Consent Form: Comparison Group

UNIVERSITY OF WASHINGTON
CONSENT FORM
Sensory-Motor Development, Learning, and Behavior in Young Children

Researcher: Tracy Jirikowic, Registered Occupational Therapist
College of Education, Department of Special Education
Telephone: 206 526-2522

Researchers' statement

I am asking you and your child to be in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions, you can decide if you want to be in the study or not. This process is called 'informed consent.' We will give you a copy of this form for your records.

PURPOSE AND BENEFITS

This study is being done in partial fulfillment of the requirements for a Doctor of Philosophy degree at the University of Washington. The purpose of this study is to learn about the sensory and motor development of young children and how this relates to their learning and behavior at home and school. Understanding more about these areas of development may help parents, teachers, and other professionals understand some types of challenging behaviors and learning differences in young children. This may also help parents and professionals recognize, and get help for some of these problems early in a child's school program.

PROCEDURES

Should you and your child decide to participate, yourself or another caregiver that knows the child well, will be scheduled for a 90 minute to 2-hour visit at the University of Washington or your home. Your child will be given some developmental tests that look at movement, thinking, and early learning skills. Examples of the test activities include building with blocks, balancing, drawing with a pencil, and beginning tasks of reading, spelling and math.

You or another caregiver will also be requested to fill out 2 checklists about your child's behavior. The checklists will take about one hour to complete. The first checklist will ask you questions about how your child responds to movement, touch, and what he or she hears and sees. This checklist is being used to see if children have different responses to sensory information. The second checklist will ask questions about how your child interacts with other children and adults, how your child is learning to eat, dress, and play, how your child listens and talks with others, and how your child coordinates his hand and body movements. The checklists will take about one hour to complete.

After getting your permission, I will also ask your child's teacher to fill out a short checklist about how your child is learning in school and how he or she plays and gets along with classmates. This checklist will take about 15 minutes to complete.

RISKS, STRESS, OR DISCOMFORT

As a researcher I am required to tell you about any risks, stress or discomfort that may occur by participating in this study. Although all test items are presented playfully as games or learning activities just like a child would complete at school, a child may become tired or frustrated during the test session. If this occurs, a break will be taken, or testing will be discontinued. Your child may also understand that he or she is being given school related tasks and asked to do tasks that are difficult, which may be stressful for him or her. Your child may miss 90 minutes to hours of class the day he or she is scheduled to be tested. Finally, some of the tests will require the test administrators to gently touch and/or move the child's hands, arms, or legs which may be uncomfortable for your child.

You may find out new information about your child's development and learning abilities. This may include information about areas of development where your child is doing well, or possibly, areas of development that are more difficult for your child. If you are interested, I can review test results and any recommendations with you after the test session by phone. This information will not be shared with your child's teacher or school.

OTHER INFORMATION

You and your child's identity will be kept strictly confidential. All information from the testing will be stored with a code number instead of names in a locked file. Names will never be made public. The final results of the study will be on file in the dissertation section of the University of Washington Library and may be published in a professional journal.

The investigator will pay for any study-related parking expenses at the University of Washington. Your child will also receive a small educational book or toy for participating in this study.

As a volunteer for this study, you may refuse to answer any question or item in either of the questionnaires. You will be able to stop the testing with your child at any time. Your child will also be told that he or she can take a break or stop testing at any time. Your participation is totally voluntary and will not affect your child's school program in any way.

Printed name of researcher | Signature of researcher | Date

Participant's statement

This study has been explained to me. I volunteer to take part in this research and give consent for my child to participate. I have had a chance to ask questions. If I have questions later about the research, I can ask one of the researchers listed above. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098. I will receive a copy of this consent form.

Printed name of participant | Signature of parent/caregiver | Date

Appendix J Parent Demographic Questionnaire

Please fill out the following questions to the best of your knowledge, if you do not want to fill out a specific question you may leave it blank.

Participant Number: ____________ **Date:** ______________

Child's Date of Birth: ___________ **Age:** _______________

Gender: M F

Household Constellation:

Single mother Single Father

Two parent household Foster parent/Guardianship

Number of siblings_________

If you checked foster/guardianship, how long has the child been in your care? ______

Highest Level of Maternal Education (Circle one):

Less than High School High School Graduate/GED Some College/Technical

College Graduate Graduate/Professional Degree

Does your child have any health, developmental or learning problems: Yes No

If yes, please list: ____

Current Special Education Program or other special service: Y or N

If yes, please list the services your child receives and frequency (e.g. 30 minutes/wk)

____

Current Grade: _______ **What is your child's race ethnicity?**

Caucasian African American Hispanic/Latino Native American,

Asian/Pacific Islander Other____________

Appendix K Teacher Letter

University of Washington
Investigator: Tracy Jirikowic
Registered Occupational Therapist
Graduate Student: College of Education

Dear Teacher,

Your student ______________ is participating in a study on learning and behavior at the University of Washington. __________ parent has given me permission to contact you and request that you fill out the enclosed form. The Social Skills Rating Scale is a tool that measures a child's social skills, behavior and academic competence in the classroom. Your perspective on the child's behavior and school performance is very important to this study and your participation is greatly appreciated. Please read the directions carefully on the test form and complete all questions. The form will take 10 to 15 minutes to complete. Please return it in the enclosed postage paid envelope as soon as possible. If you have any questions, please contact me at 206-526-2522.

Thank you very much for your time,

Sincerely,

Tracy L. Jirikowic, MS, OTR/L
Occupational Therapist

Appendix L Child Assent/Introduction Script

I am an occupational therapist and a student at the University of Washington. I am interested in how young kids play and learn in school. We are going to play some games and solve some problems so I can watch how you learn and move. We can take a break and stop anytime you feel tired. We can stop the games at anytime. Does that sound OK? Are you ready to begin?

VITA

TRACY L. JIRIKOWIC

EDUCATION
Ph.D. 2003 University of Washington, Seattle, WA, Education
M.S. 1995 University of Washington, Seattle, WA, Rehabilitation Medicine
B.S. 1991 University of Wisconsin, Madison, WI, Occupational Therapy (Honors)

CURRENT POSITIONS
University of Washington
Occupational Therapist, Clinical Specialist
Fetal Alcohol Syndrome Diagnostic and Prevention Network

Program Coordinator,
Disabilities, Opportunities, Internetworking, and Technology (DO-IT)

PROFESSIONAL CERTIFICATION

1992	American Occupational Therapy Board Certified
1995	Educational Staff Associate (ESA) Certificate, Washington State

HONORS AND AWARDS

2002	University of Washington Graduate School Gatzert Child Welfare Fellowship, Grant in support of doctoral dissertation research.
1998-2001	Trandisciplinary Leadership Personnel Preparation Training Fellowship
1995	Paula M. Carman Fellowship, Grant in support of master's thesis research.

SELECTED PUBLICATIONS
Jirikowic, T., Stika, R., Hutchison, S., Knight, A., Washington, K., Kartin, D., (2001) Contemporary Trends and Practices in Pediatric Occupational and Physical Therapy. *Physical and Occupational Therapy in Pediatrics*. Vol. 20(4)

Jirikowic, T., Engel, J., and Dietz, J. (1997). The Test of Sensory Functions in Infants: Test-Retest Reliability for Children with Developmental Delays" *American Journal of Occupational Therapy*, 51(9).

TEACHING RESPONSIBILITIES

2001-2003	Lecturer: University of Washington, Department of Special Education