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University of Alberta

Sensory Processing and Attention Deficit Hyperactivity Disorder in

Children with Fetal Alcohol Spectrum Disorder

by

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Abstract

Although sensory processing abnormalities and attention deficits are both used in the diagnosis of fetal alcohol spectrum disorder (FASD), their relationship has not previously been explored in children with FASD. A very low correlation between sensory processing, measured by the total and section scores of the Short Sensory Profile, and attention deficit hyperactivity behaviours, measured by the ADHD index of the Conners' Parent Rating Scales – Revised: Long Version, in 26 children with FASD was found retrospectively. These measures may distinguish attention deficit hyperactivity behaviours and sensory processing problems in children with FASD. Short Sensory Profile total scores indicated sensory processing problems for 81% of the children, similar to other studies of children with FASD. Auditory filtering and under-responsive/seeks sensation sections of the Short Sensory Profile indicated sensory processing problems for 73% and 88% of the children respectively. Sensory processing problems need to be considered when planning interventions.

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All those who have fetal alcohol spectrum disorder and their families who care.

TABLE OF CONTENTS

LIST OF TABLES

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FIGURES

CHAPTER 1: INTRODUCTION & LITERATURE REVIEW

Problem Statement

FASD is the most common cause of developmental delay in the western world (Abel, 1995). FASD refers to the damage caused to the fetus by alcohol exposure. The prevalence in the United States is estimated to be 9 to 10 per 1,000 births (May & Gossage, 2001; Sampson et al., 1997). In Canada, health care, social services, education, out-of-pocket expenses, and productivity losses cost an estimated $5.3 billion dollars annually for all persons with FASD from birth to 53 years (Stade et al., 2009). Quality of life is rated as significantly lower than that of typically developing peers and lower than children with cerebral palsy, blindness, deafness, cognitive impairment and cancer (Stade, Stevens, Ungar, Beyene, & Koren, 2006). Early diagnosis and qualification for intervention are associated with improved life outcomes (Streissguth et al., 2004); therefore accurate and early diagnosis of FASD and appropriate interventions are important.

Impaired sensory processing is a condition associated with FASD (Carr, Agnihotri, & Keightley, 2010; Fjeldsted & Hanlon-Dearman, 2009; Franklin, Deitz, Jirikowic, & Astley, 2008; Jirikowic, Olson, & Kartin, 2008). Sensory processing is the inhibition and excitation of relevant neurons in response to sensory input to produce an accurate perception of and response to sensations. Intact sensory processing contributes to behaviours that are adaptive to the environment (Dunn, 1997; McIntosh, Miller, Shyu, & Hagerman, 1999). Behavioural expressions of atypical sensory processing may include inattentiveness and high activity level that interfere with daily activity (Dunn).

Impaired habituation to sensation has been found in infants with alcohol exposure (Streissguth, Barr, & Martin, 1983). Four studies have explored sensory processing in children with FASD, all finding atypicality (Carr et al., 2010; Fjeldsted & Hanlon-Dearman, 2009; Franklin et al., 2008; Jirikowic et al., 2008). Indications of sensory processing abnormalities have also been found in children with diagnoses involving altered brain function such as Autism Spectrum Disorder (Kientz & Dunn, 1996; Rogers, Hepburn, & Wehner, 2003; Tomchek & Dunn, 2007; Watling, Deitz, & White, 2001), Fragile X Syndrome (Rogers et al., 2003) and Attention Deficit Hyperactivity Disorder (ADHD) (Ermer & Dunn, 1997; Dunn & Bennett, 2002; Mangeot et al., 2001; Parush, Sohmer, Steinberg, & Kaitz, 1997; Yochman, Parush, & Ornoy 2004). Given evidence of impaired sensory processing in children with FASD and findings indicative of abnormal sensory processing in persons with atypical brain function, further investigation of sensory processing in children with FASD is warranted.

There is a strong association between FASD and attention deficits, and an association between abnormal sensory processing and attention deficits. The prevalence of ADHD is high in persons with FASD and has been estimated at 65% (Clark, Lutke, Minnes, & Quellete-Kuntz, 2004), 73% (Burd, Klug, Martsolf, & Kerbeshsian, 2003), and 95% (Fryer, McGee, Matt, Riley, & Mattson, 2007). Attention deficits may present differently in children with FASD. Coles (2001) reported that ADHD typically presents as a deficit in maintaining information in working memory and shifting attention in persons with FASD, rather than with inattention, impulsivity and hyperactivity. O'Malley and Nanson (2002) reported that it presents as inattention with earlier onset and more psychiatric co-morbidities. In their landmark study of children with FASD, Streissguth et al. (1984) found errors on a test of vigilance but did not find hyperactivity. Despite the strong association of attention deficits with the diagnosis of FASD, the exact pattern of presentation of deficits is not clear. Although the expression of ADHD appears to differ in children with FASD, and although atypical sensory processing has been found in children who have ADHD (Dunn & Bennett, 2002; Ermer & Dunn, 1997; Mangeot et al., 2001; Parush et al, 1997; Yochman et al., 2004), the relationship between ADHD behaviours and sensory processing in children with FASD has not been explored.

The relationship between sensory processing and attention is important to consider as they are separately linked to adaptive behaviour. Theory (Ayres, 1979; Dahl Reeves, 2001) and research (Bar-Shalita et al., 2008) link sensory processing and adaptive behaviour in other diagnostic groups. Children with ADHD have impaired adaptive function across socialization, communication, and daily living domains (Stein, Szumowski, Blondis, & Roizen, 2006; Sukhodolsky et al., 2003). There is a high rate of impaired adaptive behaviour in persons with FASD with scores consistently below norms (Crocker, Vaurio, Riley, & Mattson, 2009; Whaley, O'Connor, & Gunderson, 2001) and below other measures of brain function such as IQ (Kaemingk & Paquette, 1999; Striessguth et al., 1991). Additionally, adaptive function decreases over time relative to norms (Kaemingk & Paquette, 1999; Striessguth et al., 1991). Seventy to 90% of persons with FASD do not achieve independent living and 50% are unemployed, including those with IQs in the average range (Clark et al., 2004; Spohr, Willms, & Steinhausen, 2007; Streissguth et al., 2004).

Further research is needed into the relationship between sensory processing and attention deficit behaviours in children with FASD. Scores on a measure of sensory processing discriminated between a group of children with FASD and controls (Jirikowic et al., 2008); and scores have been correlated with measures of behaviour problems (Franklin et al., 2008), sleep disturbances (Fjeldsted & Hanlon-Dearman, 2009), and adaptive behaviour deficits (Jirkowic) in children with FASD. However, no study has examined the relationship between sensory processing and attention deficit in persons with FASD. Greater knowledge of the expression of FASD-related brain damage will assist in the diagnostic process and may be used to target interventions towards the underlying causes of dysfunction.

A degree of relationship between sensory processing and attention deficit behaviours is expected based on neuroanatomy and neurophysiology, and on empirical findings employing the measure of sensory processing commonly used in the FASD diagnostic process. Although four studies have found atypical sensory processing in children with FASD, the association between ADHD and atypical sensory processing in these children has not been explored. Greater knowledge of the relationship between sensory processing and attention deficit behaviours in children with FASD is needed to improve the diagnostic process and to target interventions.

FASD Diagnostic Process

Measurement of brain function and determination of organic brain damage secondary to alcohol exposure is complex and multifaceted. The primary teratogenic effect of alcohol is on the fetal brain with few children having the facial dysmorphology or restricted growth that are indicative of alcohol exposure. Accurate measurement and analysis of the domains of brain function are therefore essential for correct diagnosis. According to the 4-Digit Code (Astley, 2004), the diagnostic criteria for FASD are severe impairments that are indicative of organic brain damage in 3 of 8 brain domains. These eight domains are: IQ, memory, attention, academics, executive function, communication, adaptive behaviour, and motor skills and sensory processing.

The unique nature of fetal alcohol spectrum disorder makes identification of a pattern of brain function deficits formidable (Astley et al., 2009). Areas and extent of brain damage varies in relation to numerous factors such as the pattern, timing, and amount of alcohol exposure; genetic factors; experience of abuse and neglect; and maternal malnutrition, stress, and poly-pharmacy including street drugs (Abel & Hannigan, 1995; Armstrong & Abel, 2000). As a result of the numerous factors there is wide variation in the domains of brain dysfunction across individuals with FASD. For example, a child may have a profound memory deficit but above average motor skills. Their sibling may have severely impaired motor skills but average academic abilities. Wide variation is also found within individuals. For example, a child may have intact visual memory but impaired verbal memory. It is also challenging to isolate the measurement of a single brain domain during standard clinical testing. For example, a memory deficit may affect recall of verbal information during tests of language.

ADHD and impaired sensory processing may be domains of brain dysfunction that overlap, however the potential overlap has not been investigated. Clarification of the relationship between attention deficits and sensory processing is needed as attention deficits and impaired sensory processing are both potential indicators of impaired brain function and contribute towards an FASD diagnosis.

Neuroanatomy of Attention and Sensory Processing

Based on neuroanatomy, a degree of relationship between atypical sensory processing and attention deficit behaviours is expected. Although brain areas involved in attention processes generally differ from areas involved with processing of sensory input, circuits connecting the areas provide a route via which excess neuron firing in response to sensation may influence attention, impulsivity, and activity level. The brain areas primarily responsible for processing sensory input are the thalami. Abnormalities have been found in the thalami of children with FASD (Clark, Li, Conry, Conry, & Loock, 2000; Fagerlund, et al., 2006; Lebel et al., 2008). Abnormal function of the thalami is theorized to have an impact on attention via cortico-striatal-thalamo-cortical circuits (Kinomura, Larsson, Gulyas, & Roland, 1996; Makris, Biederman, Monuteaux, & Seidman, 2009; Seidman, Valera, & Bush, 2004). Therefore, attention and sensory processing networks may influence each other.

Physiological Responses of Children with Impaired Sensory Processing

Atypical sensory processing as measured using the Short Sensory Profile (SSP) and the longer version Sensory Profile (Dunn, 1999) has been linked to atypical physiological responses. The SSP is a commonly used measure with children who may have FASD (Astley, 2004; Carr et al., 2010; Chudley et al., 2005; Franklin et al., 2008; Jirikowic et al.,

2008) and in sensory processing research. The validity of the SSP to measure atypical sensory processing is supported by the parasympathetic nervous system changes, as measured by cardiac responses on exposure to various sensory stimuli, of 9 children with SSP scores that were three standard deviations below the mean. The parasympathetic functions of the nine children differed from six typically developing children ($p < .05$) (Schaaf, Miller, Seawell, & O'Keefe, 2003).

Sympathetic nervous system function as measured by electrodermal response, that is increased eccrine sweat gland activity, is associated with strong positive or negative emotions. Electrodermal changes in response to sensory stimulation presented to 19 children, who were identified by occupational therapists as having impaired sensory processing, also differed from controls ($p < .05$) (McIntosh et al., 1999). McIntosh et al. also found differences in scores ($p < .02$) on a condensed version of the Sensory Profile between a group with moderate sympathetic nervous system responses and a group with hypo- or hyper-responses. Therefore, the neuroanatomical and neurophysiological links between sensory processing and attention deficits are supported by empirical findings.

ADHD Patterns and Sensory Processing

Several studies found an association between impaired sensory processing and attention deficits as ratings of children with attention deficits have differed from those of typically developing children on the SSP and the Sensory Profile (Dunn, 1999). Dunn and Bennett (2002) used the Sensory Profile, which contains 14 sections categorized according to type of sensory input, or type of emotional or behavioural response to input, to study 70 children who were diagnosed with ADHD according to DSM-IV criteria (American Psychiatric Association, 2000). Differences between children with ADHD and typically developing controls were significant across all Sensory Profile sections ($p < .0001$), with small to moderate effect sizes (.15 to .63).

Using the same methodology as Dunn and Bennett (2002), Yochman et al. (2004) found 11 of the 14 Sensory Profile section scores differed for 48 children with ADHD in comparison to 46 typically developing children. Ermer and Dunn (1997) found the Sensory Profile factor of inattention/distractibility best discriminated a group of 61 children clinically diagnosed with ADHD from typically developing controls.

Mangeot et al. (2001) found atypical autonomic nervous system responses and ratings indicating impaired sensory processing on the SSP in a group of 26 children clinically diagnosed with ADHD. Children with ADHD as confirmed by a parent report measure, differed from typically developing children on electrodermal response indicating adverse emotional response to sensory stimuli. In the children with ADHD, all SSP section scores differed from those of controls ($p < .05$) and had greater variability ($p < .05$). Parents' perception of children's cognitive, social, emotional, and sensory functioning on the Leiter International Performance Scale subscales (Roid & Miller, 1997) was also significantly different ($p < .001$). Mangeot et al. suggested that impaired sensory processing might be a feature of a subgroup of children with ADHD.

Studies of Children with FASD using the SSP

Two studies have found differences in sensory processing, as measured by SSP total scores, between groups of children with FASD and controls. Jirikowic et al. (2008) found that 25 children diagnosed with FASD according to the 4-Digit Code (Astley, 2004) differed from typically developing controls on the SSP total score ($p < .001$), and the SSP sections of under-responsive/seeks sensation, auditory filtering, tactile sensitivity, and visual/auditory sensitivity ($p \leq .008$). Group differences did not reach statistical significance for the remaining sections, taste/smell sensitivity, movement sensitivity, and low energy/weak. The SSP total scores of 31 children diagnosed with FASD according to the Canadian Guidelines (Chudley et al., 2005) differed from those of exposed children who did not receive an FASD diagnosis ($p = .009$) (Carr et al., 2010). However, the groups differed only on taste/smell sensitivity and low energy/weak section scores ($p < .05$). Therefore, evidence exists of atypical sensory processing in children with FASD although the pattern of expression has varied.

An association between atypical sensory processing and adaptive behaviour deficits has been explored in two studies of children with FASD. Jirikowic et al. (2008) found that SSP total scores were moderately correlated with the Scales of Independent Behavior – Revised (Bruininks, Woodcock, Weatherman & Hill, 1996) ($r = .42$; $p < .05$), a measure of adaptive behaviour. Using a different measure of adaptive behaviour, the General Adaptive Composite of the Adaptive Behavior Assessment Scale (Harrison & Oakland, 2000), Carr et al. (2010) found a weak, non-significant correlation with the SSP total score ($r = .27$). The relationship between adaptive behaviour impairments, a hallmark of FASD, and sensory processing is uncertain.

As predicted by sensory processing theory, associations between impaired sensory processing and sleep fragmentation, and between impaired sensory processing and problem behaviours have been found. Sleep disturbance in infancy is an early characteristic of FASD (Landesman-Dwyer, Keller, & Streissguth, 1978; Rosett et al. 1979). Fjeldsted and Hanlon-Dearman (2009) found atypical scores on the Infant/Toddler Sensory Profile (Dunn, 2002) were correlated with less daytime sleep ($p = .01$) and more night wakening ($p = .04$) in 20 prenatally alcohol-exposed infants from birth to 36 months of age who were diagnosed according to the Canadian Guidelines (Chudley et al., 2005).

Franklin et al. (2008) linked SSP scores indicative of impaired sensory processing to behaviour problems in 44 children diagnosed with FASD according to the 4-Digit Code. A strong negative correlation ($r = -.72$; $p < .05$) was found between the total score on the SSP and on the Child Behavior Checklist (Achenbach, 1991; Achenbach & Rescorla, 2001). This negative relationship was expected as lower SSP scores indicate impaired sensory processing and higher Child Behavior Checklist scores indicate behaviour problems. Children rated as having more behaviour indicative of impaired sensory processing were rated as having more social, thought, and attention problems ($p < .01$), more rule-breaking behaviour ($p = .04$), and more externalizing behaviour (p = .02). Children rated as having more behaviour that was indicative of impaired sensory processing in the SSP auditory filtering and under-response/seeks sensation sections were also rated in clinical or borderline ranges on the Child Behavior Checklist (p < .01). Children with SSP scores falling greater than one standard deviation from the mean were more likely to be rated with behaviour problems as 84% of the sample fell in these ranges on both measures. Preliminary evidence suggests the presence of impaired sensory processing and the association of impaired sensory processing with poor adaptive behaviour and behaviour problems, both of which are common in persons with FASD.

Summary of the Present State of Knowledge

An association between impaired sensory processing and attention deficits was expected based on neuroanatomical and neurophysiological evidence as well as research findings. Impaired sensory processing, as measured by the Sensory Profile and SSP (Dunn, 1999), has been linked to an ADHD diagnosis. SSP scores of pediatric groups with diagnoses involving impaired sensory processing, including FASD, have been related to deficits on measures of adaptive behavior. Although the rate of attention deficits is high and its presentation may be atypical, the relationship between impaired sensory processing and attention deficits has not been examined in persons with FASD.

Purpose of the Study

The strength of the relationship between sensory processing as measured by the SSP Total Score and attention deficit as measured by the ADHD Index score on the commonly used measure of ADHD behaviour, the Conners' Parent Rating Scales – Revised, Long Version (CPRS-R: L) (Conners, 1997) (ADHD score), in a sample of children with FASD was determined. The pattern of relationship between sensory processing and the ADHD index score was indicated by the strength of correlations between the SSP subscale scores and the ADHD index score. Knowledge of the strength and pattern of relationships between the sensory processing scores and the ADHD index score guides use of the SSP in diagnosis of FASD and suggests directions for intervention.

Hypothesis

For children aged 5 to 10 years at time of FASD diagnosis at the Glenrose Rehabilitation Hospital FASD Clinical Services (Glenrose Rehabilitation Hospital), it was hypothesized that there would be:

1) A strong and significant correlation ($r > -.70$) between the SSP total score and the ADHD score.

2) Strong and significant correlations ($r > -.70$) between tactile sensitivity, visual/auditory sensitivity, under-responsive/seeks sensation, auditory filtering and the ADHD score.

3) Small correlations between movement sensitivity, taste/smell sensitivity, low energy/weak and the ADHD score.

Lower SSP scores indicate poorer sensory processing and higher ADHD scores indicate more attention deficit behaviour. Therefore, a negative correlation indicates that poorer sensory processing is associated with more attention deficits.

CHAPTER 2: METHOD

Participants

Participants were a retrospective convenience sample of 26 children, who at the time of diagnosis were 5 to 10 years of age and had a complete SSP and CPRS-R: L. SSP norms apply only to children 5 and 10 years of age and therefore older and younger children were not included. Siblings were eliminated as the SSP and the CPRS-R: L are parent report measures. Inclusion of judgment-based ratings of two or more children by the same parent might bias results. Four children were not included in the sample as they had biological siblings in the sample or, if they were not biologically related, they had the same adoptive or foster parent. The sibling with the full scale IQ closest to the mean full scale IQ of the sample was included.

All participants had to have a diagnosis of FASD. Children were referred to the Glenrose Rehabilitation Hospital by physicians upon the request of parents, schools, and social workers, or at the initiative of the physicians themselves, which reflects the referral system for children to FASD diagnostic clinics across Alberta. Children are diagnosed only if they have lived with their primary caregiver for at least 6 months prior to the assessment. All team members involved in the FASD diagnostic process had more than 5 years of experience in assessing children with mild to moderate neurologically-based disorders and had training in use of the 4-Digit Code (Astley, 2004).

Parents provided written consent to use of their child's data upon admission to the diagnostic clinic. The Health Research Ethics Board approved data collection and use as described under the methods section. See Appendix A for a copy of this approval.

Procedures

The principal investigator collected all data retrospectively from the clinical records of participants using a data-tracking sheet. The principal investigator rechecked 100% of SSP data and 50% of all other data collected against the clinical records of the participants to ensure accuracy of collection. Other than 1 adaptive behaviour score and 1 full scale IQ score, no data from the SSP, CPRS-R: L, other diagnostic measures, or the demographic characteristics were incorrect.

Caregivers completed the SSP, CPRS-R: L, and Adaptive Behavior Assessment Scale – 2nd Edition Parent Form (Harrison & Oakland, 2000) at the time of assessment. The general adaptive composite scores (GAC) from the Adaptive Behavior Assessment Scale – 2nd Edition Parent Form were recorded to examine the relationships between sensory processing, ADHD behaviours, and adaptive behaviour. Clinic psychology assistants scored and neuropsychologists with doctoral degrees interpreted the CPRS-R: L and Adaptive Behavior Assessment Scale -2nd Edition Parent Form according to procedures standardized in the test manuals. The ADHD index scores of children with FASD were interpreted according to gender-related and age-related norms. The author, an occupational therapist administered, scored, and interpreted the SSP according to standardized procedures in the test manual.

Demographic and diagnostic data as per the 4-Digit Code, except IQ, were determined on the date of assessment and were recorded in the medical record by the professional who gathered the information. Clinic psychologists interpreted a recently administered IQ test. If recent IQ test results were not available, clinic psychology assistants administered an IQ measure under the supervision of clinic neuropsychologists. Clinic social workers recorded the identity of and length of relationship with the primary caregiver, and the child’s ethnicity as reported in social services records or as reported by the parent or legal guardian.

Diagnostic classifications of types of FASD were made according to the 4-Digit Code on the day of or day after assessment. The clinic pediatrician measured for and recorded the absence or presence and extent of characteristics of fetal alcohol syndrome (FAS). The term FAS refers to dysmorphology caused by prenatal alcohol exposure, generally indicating heavier alcohol exposure and more severe presentation. Partial FAS refers to presentation of some dysmorphology caused by alcohol. The diagnostic classification of static encephalopathy is neurobehavioural abnormality without dysmorphology.

Post-natal ranks as measured by the 4-Digit Code (Astley, 2004) were recorded to examine the potential impact of adverse post-natal events on the relationship between sensory processing and ADHD behaviours. Adverse factors were determined through review of the clinical, social service, and school records; interview with the caregiver and/or social worker; and medical examination performed on the date of the assessment.

Descriptive measures

The 4-Digit Code (Astley, 2004) has had the most extensive clinical validation of any FASD diagnostic guideline. It was initially developed through review of the files of over 2,000 patients who were diagnosed by interdisciplinary clinical teams. Three revisions have been based on studies of effectiveness and feedback from over 70 multidisciplinary teams. Inter-rater reliability was 94% (Astley & Clarren, 2000). Performance on standardized norm-referenced tests of the domains of brain function are ranked on a 3-point Likert scale according to the number of standard deviations from the mean that the score falls. Performance on all measures of brain function discriminated between FASD diagnostic classification groups and discriminated all diagnostic classification groups from controls (Astley et al., 2009). A measure of sensory processing was not included in their study. The 81 children with FASD were aged 8 to 15.9 years (mean age ~ 12 years) and 60% were Caucasian. Although their proportion of gender (45 males to 36 females) was comparable to the current study, children in the current study were younger (*M* = 7.5 years, range 5.5 - 10 years) and there were more Aboriginal children (65% in comparison to 17%).

The ages and ethnicities of the samples of children with FASD may differ for several reasons. Children may be diagnosed at younger ages if they have more severe presentations of

FASD. Younger age of diagnosed children may also indicate that persons initiating the referrals are more aware of the possible presentations of FASD including behaviour and sensory processing challenges, and ADHD. Differences in ethnicity may be a reflection of possible referral bias. That is, Aboriginal children are over-represented in the child welfare system and persons initiating referrals may more readily think of FASD as a cause of their difficulties. Therefore, age, severity of presentation and ethnicity were considered in interpretation of findings.

The 4-Digit Code (Astley, 2004) post-natal rank is a Likert Scale measure of the incidents that occurred in the post-natal period that may have had an adverse effect on development. Such incidents include: abuse, neglect with failure to thrive, multiple residential placements, and head injury or other medical conditions that may have led to brain damage. Post-natal rank is assigned according to 4-Digit Code criteria; 1 indicates the absence of adverse incidents, 2 indicates the presence of mild post-natal factors, 3 and 4 indicate moderate to severe incidents respectively.

The Adaptive Behavior Assessment Scale -2nd Edition Parent Form assesses the strengths and limitations of function of 5 to 21 year olds in the home and community by parent or caregiver ratings. Ratings were made on a four point Likert scale. Item selection, according to relevance and strong psychometrics, was based upon expert review and multiple field trials. Norms for children aged 5 to 10 years were established in 1998 and 1999 from a sample of 820 children in the United States. The ethnicity of approximately 1% to 2% was classified as ‘other’. Data from 15 diagnostic groups that did not include children with FASD formed approximately 5% of the normative sample.

The internal consistency coefficient of the GAC scores for the normative sample ranged from .97 to .99. The standard error of measurement for the GAC scores for the combined clinical and non-clinical normative samples ranged from 1.50 to 2.12. The GAC score has a standard deviation of 15. For ages 5 to 9 years, test-retest reliability was .91, and inter-rater reliability was .88. As expected, correlations between the GAC scores and the Adaptive Skill Area scores and adaptive domain composite scores ranged from .74 to .94. The goodness of fit of the confirmatory factor analysis was .91 (Tucker-Lewis Index) based on a one-factor model. GAC scores discriminated children with learning disabilities from controls matched for age, sex, education of self or parent, ethnicity, and region of residence ($p < .01$, Cohen's $d = .82$). GAC scores also discriminated a group of children with ADHD from matched controls ($p < .01$, Cohen's $d = .59$). The correlation between the GAC and the Vineland Adaptive Behavior Composite scores was .75.

Measures of Sensory Processing and ADHD Behaviour

Short Sensory Profile (Dunn, 1999): The SSP is the only standardized norm-referenced measure of a child's sensory processing abilities that provides a single standard score (Dunn, 1999). A single score is needed for ranking on the Likert scale used for the 4-Digit Code requirements (Astley, 2004). Additionally, a wider range of sensory inputs is evaluated than is evaluated by other sensory measures (Dunn, 1994). The SSP has been widely used in research of impaired sensory processing and is the only measure used in research with the school-aged children who have FASD (Carr et al., 2010; Franklin et al., 2008; Jirikowic et al., 2008). It is also family-centered, as it is based on parental judgment of behaviour in real-world contexts. Grade 4.9 reading level is needed to complete it. The SSP is feasible to use in the clinic setting, as it does not require certification or extensive testing in a specialized environment with specialized equipment.

Norms for the SSP were developed in the 1990s from a sample of 1,037 children in the United States aged 5 to 10 years (Dunn, 1999). Children who were receiving regular prescription medication or special education services were excluded. The degree to which the sample was representative of the ethnicity, sex, SES, or geographic region of the United States population was not discussed. The proportion of Aboriginal children was approximately 0.9%, which is substantially lower than that of the Glenrose Rehabilitation

Hospital sample. Some studies have found that norms of the Sensory Profile, the long version of the SSP, are applicable to children of non-Caucasian ethnicities (Cheung & Siu, 2009; Neuman, 2006). However, no studies have examined sensory processing in a North American Aboriginal population. Although the SSP is the most appropriate measure of sensory processing in the pediatric FASD population, the effect of ethnicity needed to be considered in interpretation of findings.

SSP items are organized into seven sections according to type of sensory input; tactile, taste/smell, movement, and visual/auditory sensitivity; or response to sensory input; under-responsive/seeks sensation, auditory filtering, and low energy/weak. Examples of SSP items are, “holds hands over ears to protect ears from sound”, and “covers eyes or squints to protect eyes from light”. Items are rated on a four-point Likert scale. The SSP also yields section standard scores.

The 38 items of the SSP were taken from the 125-item version, the Sensory Profile (Dunn, 1999). During development of the SSP, expert review eliminated all items relating to fine motor skills and social/emotional responses to input, as they were not consistent with some of the theoretical constructs of sensory processing (Dunn). Item-to-total correlations, principal component factor analyses, and item elimination resulted in the final 38 items. Nine of the items included in the SSP had been rated as occurring more often than 25% of the time in typically developing children during development of the Sensory Profile (Dunn & Westman, 1996).

Internal consistency of the total scores for the SSP using Cronbach’s alpha was .96 and ranged from .69 to .89 for section scores (Dunn, 1999). Intercorrelations of the total scores and the section scores ranged from .25 to .80. Principal components factor analysis found factor loadings were high (>.40) for all except three items, two tactile sensitivity items, and one visual/auditory sensitivity item. Additionally, 75% of the items had factor loadings above .50.

SSP items discriminated ($p < .05$) a clinical sample of 117 children likely to have sensory processing abnormalities from a typically developing sample of 37 children (Dunn, 1999). The samples were not matched on age, gender, ethnicity, SES, or region of residence. No children with FASD were in the clinical sample. Both samples included children up to the age of 17 years, beyond the age of 10 years to which SSP norms apply.

Validity of the SSP is supported by links between various neurophysiological measures of adverse response to sensory stimulation and atypical sensory processing as indicated by the SSP in children across differing diagnostic groups as discussed earlier (Mangeot et al., 2001; Schaaf et al., 2003). Davies and Gavin (2007) measured brain electrical response to sensory stimulation using event related potential and training to conditioning ratio. A maturational effect accounted for 34% of the variance in 22 typically developing children but only 1.4% in the same-aged group with sensory processing difficulties. Additionally, 6 of 7 SSP sections differed between the groups ($p < .001$).

Further evidence of validity is the association of atypical SSP scores with measures of behavioural problems across groups of children with various diagnoses as predicted based on sensory processing theory. Mangeot et al. (2001) found the under-responsive/seeks sensation, tactile sensitivity, and auditory filtering section scores of the SSP correlated with ratings of aggression ($p < .05$) in 26 children with ADHD and 30 typically developing peers. SSP scores correlated with the cognitive-behavioral tasks section of the School Function Assessment (Coster, Deeney, Haltiwanger, & Haley, 1998), although the correlation ($r = .49$) was not statistically significant in 15 boys with fragile X syndrome (Baranek et al., 2002). Maladaptive behavior scores of the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984) were correlated with most SSP sections ($r = .35$ to $.53$, $p < .001$) in 54 children with autistic disorder (Lane, Baker, & Angley, 2010). In children with FASD, Jirikowic et al. (2008) found a linear trend ($p = .002$) between SSP total scores and the maladaptive behavior index of the Scales of

Independent Behavior – Revised (Bruininks et al., 1996). Similarly, the Child Behavior Checklist total scores (Achenbach, 1991; Achenbach & Rescorla, 2001) of 44 children with FASD were highly correlated with SSP total scores ($r = -.72$, $p \leq .05$; Franklin et al. 2008).

SSP scores have also been linked to difficulties with self-care and independent living skills on measures of adaptive behaviour. Jirikowic et al. (2008) found SSP total scores were correlated ($r = .42$, $p < .05$) with broad independence scores on the Scales of Independent Behavior – Revised (Bruininks et al., 1996). Scores of 44 children clinically identified with sensory modulation disorder and having SSP and Sensory Profile scores that were 2 standard deviations below the mean differed significantly ($p < .001$, effect size = 2.25) from those of 34 typically developing controls (Bar-Shalita et al., 2008). The SSP total scores of the controls were within 1 standard deviation of the mean. Correlations with the quality of task performance ($r = .72$) and enjoyment of performance ($r = .42$) on a different measure of adaptive behaviour were significant ($p < .001$).

Validity of the SSP is also supported by agreement of SSP scores with its longer version, the Sensory Profile (Bar-Shalita et al., 2008). A weighted kappa coefficient (.81) indicated substantial agreement between SSP scores and Sensory Profile scores of the typically developing children and children with sensory processing difficulties.

The sensitivity and specificity of the SSP is not known. Studies of large samples of children taken from non-clinical populations indicate that the SSP may over identify the prevalence of sensory processing difficulties. Ahn, Miller, Milberger, and McIntosh (2004) found 5.3% of 710 children aged 4 to 6 years had SSP total scores that were greater than 3 standard deviations from the mean. Similarly, 6% of the 134 children aged 6 to 10.75 years studied by Engel-Yeger (2008) had SSP total scores falling two or more standard deviations from the mean. This prevalence was found even though children with neurological diagnoses and learning disabilities were excluded from the sample. Gouze, Hopkins, LeBailly, and Lavigne (2009) excluded children with autistic spectrum disorder, pervasive developmental disorder, an IQ below a standard score of 70, and children receiving special education, from a sample of 796 4-year-olds. They found that 11.6% of SSP total scores fell greater than 2 standard deviations from the mean. Additionally, SSP total scores differed across Caucasian, African-American, and Hispanic groups ($p < .001$) and between sexes ($p < .05$).

Conners' Parent Rating Scale-Revised: Long version (Conners, 1997): The CPRS-R: L is a common measure of attention deficit used in the diagnostic process of FASD (Chudley et al, 2005; Astley, 2004). It is a standardized judgment-based questionnaire in which a caregiver rates the similarity of a child's behaviour to a description of attention deficit behaviour on a Likert scale. The ADHD index of the CPRS-R: L contains items that best distinguish children with attention deficit from typical children and the ADHD score is the most widely accepted single measure of ADHD (Conners, 1997).

CPRS-R: L norms were established from 1993 to 1996, based on a sample of more than 4,700 children who were representative of children in Canada and the United States from ages 6 to 11 years. The developmental status of children in the normative sample is not described. Authors report "cross-cultural applicability" (p. 40, Conners, 1997) although the proportion of aboriginal children was 1%. The ADHD scores of the Native American group differed from those of five other ethnic groups ($p = .008$) (Conners, 1997). Whether the mean ADHD score of the Native America group was higher or lower or of greater variance was not specified. Internal reliability coefficients for the ADHD scores were .91 to .94 for both genders.

Items of the CPRS-R: L were retained if they loaded greater than .30 on a respective factor and less than .30 on other factors in factor analysis. The seven factors of the CPRS-R: L accounted for 50.8% of the total variance (Conners, 1997). Sensitivity and specificity were 92.3% and 98.1% respectively. CPRS-R: L test-retest correlation was .72.

The correlations between the ADHD scores of the CPRS-R: L and the Conners' Teacher Ratings Scales-Revised: Long were moderate (.49) as expected for males and females. The correlation between the ADHD scores and the hyperactivity index of a previous version of the CPRS-R: L, the Conners' Parent Rating Scale-93 (Conners, 1989), for 25 children was .89 ($p < .05$).

Discriminant validity of the ADHD score is supported by a number of studies. All items composing the ADHD score of the Conners' Parent Rating Scale-Revised: Short version are the same as the items composing the ADHD score of the CPRS-R: L. When constructing the Conners' Parent Rating Scale-Revised: Short version, Parker, Sitarenios, and Conners (1996; as cited in Conners, 1997) found that all items of the ADHD score discriminated ($p < .001$) 52 children with an ADHD diagnosis given according to DSM-IV criteria (American Psychiatric Association, 2000) from 52 children in regular education who were matched on age, sex, and ethnicity. The overall correct classification rate was 95.2% and a kappa was 0.90.

The CPRS-R: L discriminated ($p < .001$) between a group of 91 children diagnosed with ADHD according to the DSM-IV (American Psychiatric Association, 2000); 91 children from the test normative sample who were matched to the first group on age, sex, and ethnicity; and 55 children with ratings from a psychologist or psychiatrist indicating emotional problems (Conners, 1997). The ADHD score was higher for the children with ADHD diagnoses, controlling for age, than the children from the normative sample group or the group with ratings of emotional problems.

CHAPTER 3: RESULTS

Participants

All studies of sensory processing in the FASD population have used convenience samples. Demographic and clinical characteristics of all study samples are reported to identify any unusual aspects of the participants in the current study (see Table 1). The mean age of 7.5 years and the higher proportion of boys than girls of the Glenrose Rehabilitation Hospital sample were similar to other studies.

Table 1

Gender, age, and ethnicity of samples across studies

Characteristic	Glenrose (*N* = 26)	Jirikowic et al. (*N* = 25)	Franklin et al. (*N* = 44)	Carr et al. (*N* = 46)
Gender				
Male	17 (65.4%)	14 (56%)	30 (68.2%)	20 (66%)
Female	9 (34.6%)	11 (44%)	14 (31.8%)	11 (36.6%)
Age in years				
Mean (*SD*)	7.5 (1.4)	6.5 (0.88)	Not reported	8 (~ 2.8)[a]
Range	5.5 – 10.0	5.0 – 8.0	5.0 – 6.11 (31.8%) 7.0 – 8.11 (38.6%) 9.0 – 10.1 (29.5%)	3 - 14
Ethnicity				
Aboriginal	17 (65.4%)	4 (16%)[b]	4 (9.1 %)	28 (90%)
Caucasian	6 (23.1%)	12 (48%)	24 (54.5%)	1 (3%)
Other	3 (11.5%)	9 (36%)	16 (36.3 %)	2 (6%)

Note. Percentages may not total 100% due to rounding.
[a] Weighted mean ages for groups with FASD-related diagnoses and for children with alcohol exposure only. [b] Native American

The samples differ in several respects. Only the sample studied by Carr et al. (2010) contained a larger proportion of Aboriginal children. Jirikowic et al. (2008) and Franklin et al. (2008) studied smaller proportions of Aboriginal children. The proportion of Aboriginal children is pertinent as attention deficits may present atypically and may be more prevalent in this population (Baydala, Sherman, Rasmussen, Wilman, & Janzen, 2006; Conners, 1997).

The effect of caregiver identity upon parent judgment ratings of sensory processing is unknown; therefore caregiver identity was examined across samples. The Glenrose sample was largely comparable to the other studies (see Table 2). One exception was a larger proportion of adoptive parents in the Jirikowic et al. (2008) study and a smaller proportion in the Carr et al. (2010) sample, which had a larger proportion of foster parents. The number of years that children had lived with their caregiver at the time of diagnosis was longer in the current study than in the Franklin et al. (2008) study, the only study to report this characteristic. The greater time with the caregiver who completed the parent judgment-based questionnaire may result in greater familiarity with the child's responses to sensory input and therefore, more accurate ratings.

Brain dysfunction generally increases with the severity of diagnosis. Children in the Glenrose Rehabilitation Hospital sample had relatively less severe diagnoses as no children had FAS and few had partial physical features of FAS, that is, Partial FAS (see Table 2). The Jirikowic et al. (2008) sample had the most children with FAS, the diagnosis indicating greatest severity, and the Franklin et al. (2008) sample and the Jirikowic et al. sample had relatively few children with the least severe diagnosis, Neurobehavioural Disorder. Only the Carr et al. (2010) sample contained children who had alcohol exposure without an FASD-related diagnosis.

Table 2

Diagnosis and caregiver status of the samples across studies

Characteristic	Glenrose (N = 26)	Jirikowic et al. (N = 25)	Franklin et al. (N = 44)	Carr et al. (N = 46)
Diagnosis				
FAS	0[d]	5 (20%)[d]	2 (4.5%)[d]	1 (2.2%)[e]
Partial FAS	7 (26.9%)	3 (12%)	6 (13.6%)	14 (30.4%)
SE[a]	14 (53.8%)	17 (68%)	14 (31.8%)	None
NBD[b]	5 (19.2%)	None	22 (50%)	15 (32.7%)
AE[c]	None	None	None	15 (32.7%)
Caregiver				
Biological parent	4 (15.4%)	2 (8%)	10 (22.7%)	7 (15.2%)
Biological family [f]	6 (23.1%)	Not reported	10 (22.7%)	7 (15.2%)
Foster parent	8 (30.8%)	7 (28%)	8 (18.2%)	30 (65.2%)
Adoptive parent	8 (30.8%)	16 (64%)	14 (31.8%)	2 (4.3%)
Years with caregiver	M = 5.5	> 1 year	13 @ 0 – 1 year	Not reported
	SD = 2.5		12 @ 2 – 4 years	
			12 @ > 5 years	

[a] Static encephalopathy. [b] Neurobehavioural disorder. [c] Alcohol exposure only without a specific FASD diagnosis. [d] 4-Digit Code. [e] Canadian Diagnostic Guidelines. [f] Biological family other than parent

Increasing severity of brain dysfunction has been related to increased ADHD behaviours (Bhatara, Loudenberg, & Ellis, 2006; Burd et al., 2003). In consideration of the general indicators of severity, FASD diagnosis and IQ, the Glenrose Rehabilitation Hospital sample appeared to be most comparable to the Carr et al. (2010) sample. Although the FASD diagnosis of the Glenrose Rehabilitation Hospital sample was less severe overall, the effect of alcohol exposure on the brain may have been greater as indicated by the lower IQ in comparison to the Jirikowic et al. (2008) and Franklin et al. (2008) samples. However, the demographic characteristics and mean IQ of the Glenrose Rehabilitation Hospital sample were not directly comparable to the Carr et al. sample as the Carr et al. sample included children with alcohol exposure only, without an FASD diagnosis.

Table 3

Measures of intelligence across samples

	Glenrose [a] (n = 25)	Jirikowic et al. [b] (N = 25)	Franklin et al. [c] (N = 44)	Carr et al. [d] (N = 46)
Mean (SD)	80.6 (15.6)	91.2 (15.0)	Not reported	~ 80 (15)
Frequency			1 (2.6%) @ 130 -140	
			2 (5.1%) @ 115 -129	
			9 (23.1%) @ 100 -114	
			20 (51.3%) @ 85 – 99	
			6 (15.4%) @ 70 – 84	
			1 (2.6%) @ 60 - 69	

[a] Measured by the WPPSI-III, WISC-III, or WISC-IV. [b] Measured by the Test of Nonverbal Intelligence. [c] Measurement instrument not reported. [d] Mean IQ for 3 groups (partial FAS, Alcohol-related Neurodevelopmental Disorder, and alcohol exposed) measured by the WPPSI-III or WISC-IV.

Internal Consistency of SSP Total Scores and ADHD Scores

Internal consistencies of the ADHD scores, and SSP total and section scores were determined as the ethnicities of children in the Glenrose Rehabilitation Hospital sample differed from those in the normative sample. Internal consistencies of SSP total scores (Cronbach's α = .83) and ADHD scores (Cronbach's α = .89) were good. Although the internal consistencies of tactile sensitivity and movement sensitivity were weak, the internal consistencies of all other SSP section scores were good (see Table 4).

Table 4

Internal consistency of SSP section scores of the Glenrose Rehabilitation Hospital sample (*N* = 26) [a]

SSP section	Internal consistency
Tactile sensitivity	.53
Taste/smell sensitivity	.92
Movement sensitivity	.48
Under-responsive/seeks sensation	.87
Auditory filtering	.86
Low energy/weak	.91
Visual/auditory sensitivity	.83

[a] Internal reliability measured by Cronbach's α.

Distributions of SSP Total Scores and Section Scores

Raw SSP total scores and raw section scores were used for all analyses consistent with the Carr et al. (2010), Franklin et al. (2008), and Jirikowic et al. (2008) studies. SSP total scores were normally distributed with a skew of .08, kurtosis of .11, and with no outliers. A substantial majority of the SSP total scores was in the definite difference category (2 or more standard deviations from the mean) and very few were in the typically developing category (see Table 5). The mean SSP total score fell in the definite difference category at 130.81 (*SD* = 17.20, range 100 - 168). The mean of the normative sample was 168 (*SD* = 13.0). Higher scores indicate more typical responses.

Similarities of distributions of SSP total scores across studies were examined to determine the degree to which the current sample was comparable to the other samples, given the small sample was taken from a diagnostic group that has a great deal of variability in scores on many different measures (see Table 5). The distributions of SSP total scores are largely comparable. The majority of children from all samples had SSP total scores that fell in the definite difference category.

Table 5

SSP total score frequencies according to category across studies

Sample	Typically developing [a] *n* (%)	Probable difference [b] *n* (%)	Definite difference [c] *n* (%)
Glenrose (*N* = 26)	2 (7.7)	3 (11.5)	21 (80.8)
Franklin et al. (*N* = 44)	5 (11.4)	7 (15.9)	32 (72.7)
Jirikowic (2003) (*N* = 25)	3 (12)	2 (8)	20 (80)
Carr et al. (*n* = 31) [d]	3 (9.7)	9 (29)	19 (61)

[a] Typically developing scores are within 1 standard deviation of the mean or higher.
[b] Probable difference scores are within 1 standard deviation of the mean or higher.
[c] Definite difference scores are greater than 2 standard deviations from the mean.
[d] Data does not include children with alcohol exposure only.

SSP section scores were normally distributed only for the auditory filtering, under-responsive/seeks sensation, and low energy/weak sections (see Table 6). The auditory filtering distribution contained 2 outliers. Both outliers fell in the typical performance category. No other distribution contained outliers.

Table 6

Skew and kurtosis of SSP section score distributions for the Glenrose Rehabilitation Hospital sample (*N* = 26)

SSP section	Skew	Kurtosis
Tactile sensitivity	-1.02	.53
Taste/smell sensitivity	-1.56	1.68
Movement sensitivity	-1.72	5.84
Under-responsive/seeks sensation	.32	-.45
Auditory filtering	.43	.46
Low energy/weak	-.43	-1.42
Visual/auditory sensitivity	-.97	.05

The distributions of SSP section scores according to category were compared to distributions in other studies to determine the degree to which the current sample was comparable to other samples (see Table 7 and Appendix B). The large number of children with definite differences in the under-responsive/seeks sensation and auditory filtering sections were consistent across all studies. However, the Glenrose Rehabilitation Hospital sample had fewer children with probable and definite differences in taste/smell sensitivity. More Glenrose Rehabilitation Hospital children had probable differences in movement sensitivity but fewer had definite differences.

Table 7

Distributions of section scores according to category across studies

SSP sections	Study	Typically developing *n* (%)	Probable difference *n* (%)	Definite difference *n* (%)
Taste/smell sensitivity	Glenrose[a]	21 (80.8)	1 (3.8)	4 (15.4)
	Franklin et al. [b]	24 (54.5)	5 (11.4)	15 (34.1)
	Jirkowic [c]	11 (44)	4 (16)	10 (40)
	Carr et al. [d]	14 (45.5)	4 (13)	13 (41.5)
Movement sensitivity	Glenrose	12 (46.2)	12 (46.2)	3 (7.7)
	Franklin et al.	21 (47.7)	10 (22.7)	13 (29.5)
	Jirikowic	11 (44)	5 (20)	9 (36)
	Carr et al.	29 (93.5)	0	2 (6.5)
Under-responsive/ seeks sensation	Glenrose	6 (23.1)	1 (3.8)	19 (73.1)
	Franklin et al.	5 (11.4)	2 (4.5)	37 (84.1)
	Jirikowic	3 (12)	4 (16)	18 (72)
	Carr et al.	4 (13)	4 (13)	23 (74)
Auditory filtering	Glenrose	3 (11.5)	0	23 (88.5)
	Franklin et al.	5 (11.4)	2 (4.5)	37 (84.1)
	Jirikowic	0	6 (24)	19 (76)
	Carr et al.	2 (6.5)	3 (9.5)	26 (84)

[a] Glenrose $N = 26$. [b] Franklin et al. $N = 44$. [c] Jirikowic (2003) $N = 25$. [d] Carr et al. $n = 31$, that is, excluding children with alcohol exposure only.

Distribution of ADHD Scores

The distribution of ADHD scores was normal with a skew of .28, kurtosis of -.48, and contained no outliers. Most of the ADHD scores fell in the markedly atypical range with only 1 score in each of the slightly and mildly atypical ranges (see Table 8). The mean ADHD score was 74.85 (*SD* = 8.54, range 59 - 90) in comparison to the normative population mean of 50 (*SD* = 10). Higher scores indicate more attention deficits. A correction for range restriction was not done, as this distribution of scores is typical for children with FASD.

Table 8: Frequencies of Glenrose Rehabilitation Hospital children in ADHD categories (*N* = 26)

Slightly atypical [a] *n* (%)	Mildly atypical [b] *n* (%)	Moderately atypical [c] *n* (%)	Markedly atypical [d] *n* (%)
1 (3.8)	1 (3.8)	5 (19.2)	19 (73.1)

[a] T-score range = 56 – 60. [b] T-score range = 61 – 65. [c] T-score range = 66 – 70.
[d] T-score range > 70.

Correlation of SSP Total Scores and ADHD Scores

The Pearson's correlation between SSP total scores and ADHD scores was very low and not significant, $r(26) = .02$, $p = .45$, 1 tailed (see Figure 1). Therefore, there is most likely little to no relationship between ADHD behaviours as measured by the CPRS-R: L and sensory processing abnormalities as measured by SSP total scores in the Glenrose Rehabilitation Hospital sample. Although a negative correlation was hypothesized, the correlation was positive. However, the correlation was small and did not reach statistical significance, and confidence intervals for the correlation would likely include negative values.

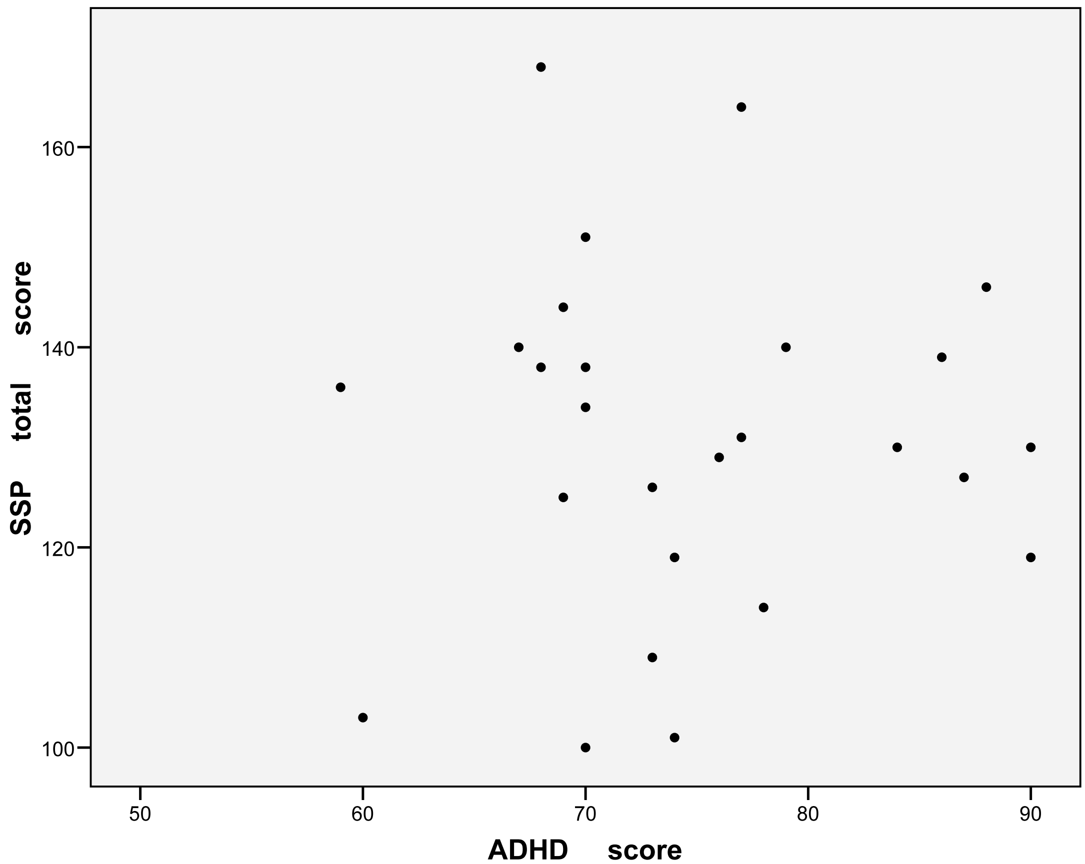

Figure 1

Correlation of SSP total scores and ADHD scores for the Glenrose sample ($N = 26$)

As the sample size was small, a correlation was done of SSP total scores and ADHD scores both categorized according to the number of standard deviations from the mean that they fell. The correlation, determined by Spearman's rho ($N = 26$), was very weak ($r = .12$, $p = .29$, 1 tailed).

In consideration of the possible influence of ethnicity on ADHD scores, separate correlations were performed for the Aboriginal children; Pearson's $r(17) = -.05$, $p = .43$, 1 tailed; and Caucasian children; Pearson's $r(6) = .26$, $p = .31$, 1 tailed. In consideration of the possible influence of adverse post-natal events on sensory processing, separate correlations were also performed for children with a post-natal rank of 1; Pearson's $r(9) = .11$, $p = .34$, 1 tailed; and a rank of 4; Pearson's $r(12) = .24$, $p = .22$, 1 tailed. The number of children with a postnatal rank of 2 (n = 2) or 3 (n = 3) was too small to include. The correlations of SSP total scores and ADHD scores were weak for both the Aboriginal and Caucasian children and for children with post-natal ranks of 1 and 4.

Correlations of SSP Section Scores and ADHD Scores

As shown in Table 9, correlations between SSP section scores and ADHD scores were weak and did not reach statistical significance. Although negative correlations were hypothesized, most correlations were positive but very small. Confidence intervals for the correlations would likely include negative values.

Table 9

Correlation of SSP Section Scores and ADHD Scores for the Glenrose sample ($N = 26$)

SSP section	Correlation (1 tailed)
Tactile sensitivity	.03*
Taste/smell sensitivity	.13*
Movement sensitivity	.10*
Under-responsive/seeks sensation	-.20*
Auditory filtering	-.19*
Low energy/weak	.04*
Visual/auditory sensitivity	.23*

* $p > .10$

Children with an SSP Total or ADHD Scores in the Average Range

The number of children with SSP total or ADHD scores near the average range was small ($n = 4$). If these children had scores near the average range on both measures, this relationship may not be evident in analyses using the full sample. Therefore, scores on the primary measures were examined for these children. The ADHD scores of the 2 children, whose SSP total scores fell in the typically developing category, were both in the moderately atypical category. The SSP total scores of the 2 children, who had ADHD scores in the slightly atypical or mildly atypical categories, were in the definite difference categories. Again, there was no evidence of a relationship between measures of ADHD and sensory processing.

Correlation of ADHD Scores and GAC Scores

The relationship between ADHD scores and GAC scores was examined to determine if the relationship of the ADHD scores with another variable in this small sample was in keeping with those found in other studies of persons with FASD. This would provide additional evidence that the sample was not unusual. There was a moderately strong and significant correlation between ADHD and GAC scores ($r = -.41$, $p = .02$, 1 tailed). A negative correlation is expected as higher ADHD scores indicate a higher incidence of ADHD behaviours and higher GAC scores indicate greater achievement in adaptive behaviours. Therefore, the relationship between ADHD scores and GAC scores was in keeping with expectations.

Correlation of SSP Total Scores and GAC Scores

The weak correlation between SSP total scores and GAC scores; $r = .32$, $p = .06$, 1 tailed; is in keeping with Jirikowic et al. (2008); r(25) = .42, p = .02, 2 tailed; and Carr et al. (2010); r(46) = .27, not significant. Variation in the strength of the correlations may be related to use of a different measure of adaptive behaviour, the Scales of Independent Behaviour – Revised (Bruininks et al., 1996), used by Jirikowic et al. Variation may also be related to the inclusion of children with alcohol exposure only by Carr et al.

CHAPTER 4: DISCUSSION

Despite theoretical, neuroanatomical, and neurophysiological links, a relationship between sensory processing problems and ADHD behaviour was not found. The correlation between sensory processing, as measured by the SSP, and ADHD, as measured by the CPRS-R: L, was very weak. Additionally, the correlations between all SSP sections and ADHD scores were very small. These results provide evidence that the SSP and CPRS-R: L measure different aspects of brain dysfunction in children with FASD. For diagnosis, this means that each can be used in the diagnostic process as a separate indicator of how alcohol has affected brain function. For intervention, one approach will likely not address challenges in both areas. Prior to looking at the implications of the study results, the evidence for the expected relationship between the sensory processing and ADHD is revisited in light of the new evidence found in this study.

A strong correlation of SSP scores and ADHD scores was hypothesized as the empirical and theoretical links between the concepts of sensory processing deficits and attention deficits are strong. Sensory processing deficits are the result of abnormal central nervous system sensitization and inhibition to sensory input (Dunn, 1997). Alcohol-exposed infants have atypical orientation to auditory stimulation (Coles, Smith, Fernhoff, Falek, 1985) and habituation to sensations (Streissguth et al., 1983). Similarly, children with ADHD are more reactive to sensations (Mangeot et al., 1999; Parush, Sohmer, Steinberg, & Kaitz, 1997). There is feedback between central nervous system networks involved in attention and sensory processing.

There is also much overlap in the behavioural expression of sensory processing impairment and ADHD. Theoretically, impaired sensory processing may be expressed as inattention, distractibility, over-arousal (Dunn, 1997 & 1999), impulsivity, and abnormal activity level (McIntosh et al., 1999). Behavioural evidence required for an ADHD diagnosis is inattentiveness, hyperactivity, and impulsivity (American Psychiatric Association, 2000).

The behavioural expression of impaired sensory processing as measured by the SSP shares similarity with the behavioural expression of ADHD. Half of the items in the under-responsive/seeks sensation section and all of the auditory filtering items on the SSP were consistent with diagnostic criteria for ADHD and were considered as confirmatory of ADHD (Dunn & Bennett, 2002). Indeed, the sensory processing of children with ADHD, as measured by the SSP or Sensory Profile, is atypical (Dunn & Bennett, 2002; Ermer & Dunn, 1997; Mangeot et al., 1999).

Given the common characteristics and empirical findings of abnormal sensory processing and ADHD, the question arose as to whether the same or highly similar brain functions were being measured by the SSP and the CPRS-R: L. Behaviour problems and poor adaptive behaviour, prevalent in children with ADHD, are also hallmarks of FASD (Burd et al., 2003; Clark et al., 2004; Crocker et al., 2009; Fryer et al., 2007; Whaley et al., 2001). Recent associations between sensory processing abnormalities and problem behaviours (Franklin et al., 2008), and between sensory processing abnormalities and impaired adaptive behaviour (Jirikowic et al., 2008) have been made in children with FASD. Based on the overlapping characteristics, it was postulated that measures of ADHD behaviours and sensory processing deficits would be highly correlated in an FASD group.

Despite many common elements, evidence from this study that the SSP and CPRS-R: L measure different brain functions in children with FASD, indicates that there are likely differences in these brain functions. A lack of correlation may be related to the different presentation of attention deficits in children with FASD than the typical presentation of ADHD (Burden et al., 2010; Coles, 2001; O'Malley & Nanson, 2002; Streissguth et al., 1984). The research suggests that children with FASD have more difficulty with working memory, shifting attention, and have more inattention, rather than hyperactivity and impulsivity. The SSP may discern over-arousal and hyperactive behaviour rather than an inattentive presentation of attention deficits.

It may also be possible that the neural mechanisms determining sensitivity and response to sensory input are fundamentally different in children with ADHD and children with FASD. Support for fundamental differences in neural mechanisms that determine sensory sensitivity and response are found in factor loadings of the Sensory Profile (Dunn & Brown, 1996). Factor loadings sorted according to sensitivity and response to input in the normative sample.

Differences in responses of children with ADHD and children with FASD to sensation may also provide evidence of differences in underlying neural mechanisms. Children with ADHD have shown atypically rapid habituation to stimuli in comparison to typically developing children (Mangeot et al., 2001; Shibagaki, Yamanaka, Furuya, 1993). Therefore, the response threshold of children with ADHD may be high. That is, they may quickly habituate and may need a high level of stimulation to maintain arousal.

Infants with alcohol exposure, in contrast, have atypically delayed habituation to sensory stimulation (Streissguth et al., 1983). The difference in reactions of children with FASD in comparison to children with ADHD may be related to a response threshold. Children with FASD may become over-stimulated as a result of lack of habituation to input resulting in a high level of arousal. Decreased habituation to sensory input is consistent with reactions of children with Fragile X Syndrome (Miller et al., 1999) and sensory modulation disorder (Davies & Gavin, 2007; McIntosh et al., 1999).

Consideration must be given, however, to the fact that neurophysiological responses of children with ADHD have not been consistent (Herpertz et al., 2001; Parush et al., 1997). Mangeot et al. (2001) found children with ADHD had greater reactions to initial stimulation than typically developing controls, but had rapid habituation. Some researchers contend that rapid habituation may be a feature of a subgroup of children with ADHD who also have conduct disorder (Herpertz et al.).

Although the neural substrate may function in different ways in children with ADHD and FASD the behavioural outcome may be similar in appearance. Children with ADHD may have typical sensitivity but may habituate more rapidly than controls. To counter-act the rapid habituation in an effort to maintain arousal they may have a high activity level, inattention, and impulsivity. Decreased habituation may produce over-aroused behaviour that presents as inattentiveness. Although the behaviours of children with FASD present as inattentive, the atypical habituation that leads to the inattentiveness is quite different than the atypical habituation of children with ADHD. The low correlation between SSP scores and ADHD scores may be because the SSP measures behaviours indicating decreased habituation to sensations whereas the CPRS-R: L measures hyperactivity and impulsivity, as well as inattention.

Sensory Processing in Children with FASD

The marked discrepancy between SSP scores of the Glenrose Rehabilitation Hospital sample in comparison to norms suggests the existence of sensory processing problems in children with FASD. Sampled children were 10 times more likely to have SSP total scores in the definite difference category, which is 2 or more standard deviations from the mean, than in the typically developing or probable difference categories. Scores in the definite difference category were 3 times as likely in the under-responsive/seeks sensation section and 8 times as likely in the auditory filtering section.

Similarities of SSP ratings in this study to those of other studies of children with FASD suggest that the Glenrose Rehabilitation Hospital sample is representative of children with FASD. It is notable that similar proportions of children with FASD had scores in the definite difference category across all studies, despite dissimilar ethnicity, full scale IQ, caregiver identity, and severity of FASD diagnosis. SSP total scores were in the definite difference category for 80.8% of the current sample, and similar proportions of the Franklin et al. (2008) and Jirikowic et al. (2008) samples. Carr et al. (2010) found a lower but large proportion of children had SSP total scores in the definite difference category. Distributions of SSP section scores were also similar across studies. The most notable trend was that the greatest proportion of under-responsive/seeks sensation and auditory filtering section scores fell in the definite difference category.

Such consistently large proportions of children having definite differences in the SSP total scores, under-responsive/seeks sensation, and auditory filtering scores across all studies (Carr et al., 2010; Franklin et al., 2008, Jirikowic et al., 2008), suggests that children with FASD may have difficulty modulating their responses to sensory input. These findings concur with those of Coles et al. (1985) who found a relationship between alcohol exposure in infants and poorer orientation to animate ($p < .02$) and inanimate ($p < .05$) auditory stimuli.

According to sensory processing theory, children who have difficulty habituating may present as hyperactive and/or distractible, and may have difficulty learning from experience (Dunn, 1997). They may be easily over-whelmed, have strong emotional reactions, and disruptive behaviour (Miller, 2007). Children who have dysfunctional habituation may be under- or over-responsive to sensory input (Dunn). Thus, dysfunctional sensory modulation may be exhibited as generalized over-arousal (Ayres, 1979; McIntosh et al., 1999; Miller, 2007).

Findings of this study also support the theory of impaired modulation of responses to sensory input. In the current study, for example, many caregivers rated children as not noticing when their face or hands were dirty, and not hearing when their names were called. Ratings also suggested that the children seek sensations, which may be secondary to over-arousal. For example, many caregivers rated children as enjoying strange noises and seeking to make noise for noise's sake.

Correlations with Adaptive Skills

Given the lack of support for hypotheses one and two with the markedly low correlations between sensory processing and ADHD, the relationship between ADHD scores and GAC scores, and between SSP total scores and GAC scores was explored to determine if the small sample behaved in expected ways in terms of other variables. Weak adaptive skills are prevalent in persons with FASD and ADHD (Crocker et al., 2009; Stein et al., 2006; Sukhodolsky et al., 2003) suggesting that the ADHD scores and GAC scores should be correlated. The moderate correlation between ADHD scores and GAC scores confirms that the current sample behaves in expected ways. It also indicated that using intervention strategies to manage ADHD behaviours might have some impact on adaptive functioning. However, the multi-faceted nature of adaptive behaviour also makes it clear that variables in addition to ADHD contribute to adaptive behaviour.

The relationship of sensory processing to adaptive functioning in this study was weak, in keeping with Carr et al. (2010) who also used the same measure of adaptive function. This suggests that addressing sensory processing in children with FASD will not likely make a large impact on their adaptive functioning. However, this result must be treated with caution due to the small sample size and contradictory results in the literature.

Jirikowic et al. (2008) found a moderate correlation between sensory processing scores of children with FASD and an alternative adaptive behaviour measure. Inconsistencies in correlations between the SSP and different measures of adaptive behaviour have been found in studies of children with other developmental disabilities. Jasmin et al. (2009), Robinson and Magill-Evans (2010), and Lane, et al. (2010) found weak correlations in children with Autistic Spectrum Disorder. Baranek and colleagues (2002) used the same measure as Lane et al. with children who had Fragile X and found a strong association with some aspects of functional behaviour. In children with sensory modulation disorder, the quality of adaptive task performance, rather than frequency or enjoyment of performance, was highly correlated with SSP total scores (Bar-Shalita et al., 2008). Observational measurement of adaptive behaviour performance by occupational therapists was strongly associated with sections of the Sensory Profile in children with sensory modulation disorder (White, Mulligan, Merrill, & Wright, 2007). It is possible that the association between the sensory processing and adaptive behaviour varies with factors related to the measurement instrument.

Clinical Implications

The possibility that impaired sensory processing and ADHD behaviours are distinct brain functions in children with FASD has implications for diagnosis. Early diagnosis is one of the strongest predictors of minimizing and preventing adverse life outcomes (Streissguth et al., 2004; Clark et al., 2004), yet it is difficult to make an FASD diagnosis prior to age 7 years. The earliest sign of central nervous system impairment may be dysfunctional habituation to stimuli (Streissguth et al., 1983). Behaviour challenges are a common reason for referral for diagnosis of FASD (Clarren & Lutke, 2008). Behavioural difficulties are strongly associated with sensory processing problems in children with FASD (Franklin, 2008). Therefore, sensory processing should be assessed in all referred children while remembering that approximately 10% of children with FASD appear to have typical sensory processing as measured by the SSP.

Although correlations in this study provide strong indications that the ADHD scores and SSP scores measure distinct brain functions, evidence of over-identification of typically developing children as having sensory processing difficulties suggests that the SSP scores do not distinguish a number of typically developing children from children who have sensory processing abnormalities. Larger than expected proportions of typically developing children have had SSP total scores that fall greater than 2 standard deviations below the mean in several studies (Ahn et al., 2004; Engel-Yeger, 2008; Gouze et al., 2009). Jirikowic et al. (2008) found a substantial portion of typically developing children had “clinically elevated” (p. 133) scores on the SSP. Findings suggest that the SSP may have a limited specificity to discriminate the sensory processing function of children with FASD from alcohol-exposed children who do not have FASD. Therefore, caution is needed when using SSP evidence of sensory processing abnormality diagnostically to distinguish these children. Information on sensitivity and specificity of the SSP is needed.

If permanent brain damage due to prenatal alcohol exposure alters the regulation of responses to sensory input, then regulation of input must occur externally. The sensory qualities of the environment, task, or person must be graded to meet the individual’s threshold (Dunn, 1997). According to sensory processing theory, results of this study suggest that the central nervous systems of children with FASD may react with equal sensitivity to all sound. Because their central nervous systems may not adequately modulate sounds, the children may, at times, react to all auditory input and at other times, react to none.

These children may benefit from being alerted to important sounds. For example, caregivers should ensure that they have the child’s attention before speaking to them. A classroom with an FM system may help the child register the teacher’s instructions. Decreasing background noise when speaking to a child with FASD may help the child process what they are being told.

The central nervous systems of children with FASD may also not modulate behavioural responses to auditory input. When registering auditory input the children may become over-aroused. As a result of over-arousal they may seek kinesthetic, visual, auditory, and tactile input. Therefore, children with FASD may benefit from environmental modifications that reduce auditory input. Classrooms should be modified to decrease noise.

People working with children who have FASD may wish to keep verbal instructions to a minimum. In noisy settings the use of earplugs or headphones may improve behaviour.

Study Limitations

A small convenience sample of clinically referred children was studied. Correlations found in a larger sample of different composition may differ. However, the correlation between SSP total scores and ADHD scores was so small that a much larger correlation is unlikely.

Although the SSP has been used in all studies of sensory processing in children who have FASD, caution is needed in interpretation of SSP and ADHD scores. Both primary measures were parent judgment-based rating scales, which may have biased results. Completion of the SSP and CPRS: R-L by a caregiver with an expectation of or desire for or against an FASD diagnosis would have increased the correlation. To decrease bias, siblings were removed from the sample. Given the low correlation in the current study, influence of expectation bias was weak at most. The number of ratings that were greater than 2 standard deviations from the mean suggests that social desirability or end-aversion biases were also not strong influences. Therefore, it appears that results of this study were not heavily influenced by biases. Less subjective and more proximal measures of sensory responses or attention, such as neurophysiological measures or brain imaging, were not available during the current study.

Children with FASD often have multi-factorial histories that are challenging to precisely quantify (Benz, Rasmussen & Andrew, 2009; Roberts & Nanson, 2000). Although the 4-Digit Code ranking of post-natal adversity allows some subjectivity and its validity has not been widely established, it is the only measure of post-natal adversity currently available.

Other aspects of measurement weakness may have attenuated the correlation. The SSP is a screening instrument. Item elimination from its longer version, the Sensory Profile, may result in over-identification of sensory processing difficulties. Several studies have found that a greater proportion of SSP scores of typically developing children fall in the definite difference category than would be expected (Ahn et al., 2004; Engel-Yeger, 2008; Gouze et al., 2009). The large age range to which the single set of SSP norms applies could also have attenuated the correlation. Developmental changes in sensory processing that occur during the rapid growth, from ages 5 to 10 years, may not be detected (Jirikowic, 2003).

The SSP and the ADHD scores are also single measures of complex behaviour. ADHD has, and sensory processing deficits may have, many forms of presentation (Miller, 2007; Spencer, Biederman, & Mick, 2007). The single ADHD score from the CPRS-R: L may not have captured the variability within a wide range of possible expressions of ADHD. Additionally, the relatively few ADHD scores falling below a T-Score of 70 may have attenuated the correlations. However, inclusion of more indicators of ADHD would have resulted in a large number of correlations using a small sample that may have detected a relationship only by chance.

There is some limited evidence that the SSP can be used with children of ethnicities other than that of the normative sample of the Sensory Profile (Dunn, 1994). Additionally, a very small portion of the normative sample was of Native American ethnicity. However, the internal consistency of the SSP total scores and sections scores was good in this study with a large proportion of Aboriginal children, except for the tactile and movement sensitivity sections, which were weak. There is evidence that ADHD may be expressed differently in Aboriginal children. However, the correlations of SSP total scores and ADHD scores, performed separately for the Aboriginal children and the Caucasian children, were both low. Therefore, the greater prevalence of ADHD in the Aboriginal group does not alter the correlation of ADHD scores and SSP total scores.

Directions for Future Research

This study is the first to examine the association between a measure of sensory processing and ADHD behaviour in children with FASD therefore, it is considered exploratory. Given the caveats of the current study, corroboration that the SSP does not duplicate measures of ADHD is needed. In consideration of the profoundly disabling effects of attention deficits and problems behaviours in children who have FASD, further research to extend the findings of the current study is needed.

Replication of this study with a larger and more diverse sample from multiple diagnostic sites may prove the significance of the low correlation between the SSP and ADHD scores. Replication with a larger sample may also allow comparison of groups of children who have both FASD and ADHD, and who are medicated and are not medicated for ADHD. If sensory processing and ADHD are distinct constructs, then correlations between medicated and non-medicated groups should not differ significantly.

Current findings may be corroborated and extended in several ways. Alternative measures of sensory processing may reinforce findings, particularly measures by non-parental observers of behaviour. Such measures may be direct observation by occupational therapists or by the teacher-report rating scale, the Sensory Profile School Companion (Dunn, 2008).

More objective and proximal measures of sensory responses and attention, such as neurophysiological measures or brain imaging would eliminate sources of bias. Electrodermal responses, somatosensory evoked potentials, and cardiac vagal tone are direct measures of neurophysiological response to sensory input. Computerized measures of ADHD behaviour such as the Conners' Integrated Visual and Auditory Continuous Performance Test eliminate biases introduced by parent rating scales. Neurophysiological measures may also provide more direct evidence of atypical sensitization and inhibition. Data from alternative measures of adaptive behaviour that have been highly correlated with sensory processing deficits may help to clarify the complex relationship between variables (Bar-Shalita et al., 2008; White et al., 2007).

Although the Sensory Profile, the long version of the SSP, is a parent-report instrument, it would provide more detailed and comprehensive evidence of sensory thresholds and response patterns. The Sensory Profile provides norm referenced ratings on nine factors which indicate the child's responsivity, the processing of six types of sensory input, five forms of modulation, and three categories of emotional and behavioural response to input. Interventions could be then target specific areas of difficulty.

Although sensory processing appears to be an area of deficit, it is possible that it is an area of developmental delay that may normalize with age. Developmental trends in sensory processing of children who have FASD may be detected by correlating SSP or Sensory Profile scores with age. This determination would suggest whether sensory interventions should be extended into adolescence and adulthood.

Knowledge of factors that contribute to the disabling problem behaviours and impaired adaptive behaviour of children with FASD are needed to direct intervention and decrease adverse life outcomes. Use of multiple regression to determine the amount of variance contributed by attention deficits and sensory processing to problem behaviours or adaptive behaviour deficits may guide intervention. A randomized control trial of the effectiveness of intervention strategies to address impaired sensory processing would provide strong evidence that sensory processing deficits exist and should be assessed and treated in this population.

In consideration of the high number of typically developing children who are identified as having sensory processing problems on the SSP, application of findings to diagnosis requires further study. Studies of larger samples of children who have FASD and typically developing children who are matched on age, gender, ethnicity, and socio-economical status are crucial to determine the extent to which the SSP discriminates children with FASD from matched controls with typical development.

CHAPTER 5: CONCLUSION

The correlation of sensory processing, as measured by the SSP, and ADHD behaviour, as measured by the CPRS-R: L, is very weak, providing evidence that these measures detect different aspects of brain dysfunction in children with FASD. Impaired sensory processing may be indicative of delayed inhibition to sensory input. ADHD may be indicative of more rapid habituation. Therefore, the SSP and CPRS-R: L may not be redundant measures of the same domain of brain dysfunction in the diagnostic process. Additionally, findings concur with sensory processing theory and with prior research, providing evidence that children with FASD have sensory processing problems, specifically difficulties with sensory modulation. Therefore, assessment of sensory processing in the FASD diagnostic process and intervention in the form of customized environmental modification are needed. Caution is needed in application of findings to diagnosis of FASD as the SSP may over-identify typically developing children as having sensory processing problems. Further research is necessary to substantiate these findings with more proximal and objective neurophysiological measures of brain imaging.

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APPENDIX A: HEALTH ETHICS RESEARCH BOARD LETTER OF APPROVAL

Approval Form

Date:	January 28, 2010
Principal Investigator:	Joyce Magill-Evans
Study ID:	Pro00011923
Study Title:	Relationship between the Short Sensory Profile and the Conners' Attention Deficit Hyperactivity Disorder Index in Children with Fetal Alcohol Spectrum Disorder
Approval Expiry Date:	January 27, 2011

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application has been reviewed and approved on behalf of the committee.

The Research Ethics Board assessed all matters required by section 50(1)(a) of the Health Information Act. The REB Panel determined that the research described in the ethics application is a retrospective chart review for which subject consent for access to personally identifiable health information would not be reasonable, feasible or practical. Subject consent therefore is not required for access to the personally identifiable health information described in the ethics application.
In order to comply with the Health Information Act, a copy of the approval form is being sent to the Office of the Information and Privacy Commissioner.
A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services administrative approval, and operational approval for areas impacted by the research, should be directed to the Alberta Health Services Regional Research Administration office, #1800 College Plaza, phone (780) 407-6041.

Sincerely,

Glenn Griener, Ph.D.
Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).

APPENDIX B: DISTRIBUTION OF SSP SECTION SCORES ACROSS STUDIES

SSP sections		Typically developing n (%)	Probable difference n (%)	Definite difference n (%)
Tactile sensitivity	Glenrose[a]	7 (26.9)	8 (30.8)	11 (42.3)
	Franklin et al.[b]	11 (25.0)	10 (22.7)	23 (52.3)
	Jirikowic [c]	8 (32)	2 (8)	15 (60)
	Carr et al.[d]	12 (39)	5 (16.5)	14 (44.5)
Low energy/ weak	Glenrose	13 (50.0)	3 (11.5)	10 (38.5)
	Franklin et al.	19 (43.2)	6 (13.6)	19 (43.2)
	Jirikowic	13 (52)	1 (4)	11 (44)
	Carr et al.	18 (58.5)	2 (6.5)	11 (35)
Visual/auditory sensitivity	Glenrose	14 (53.8)	5 (19.2)	7 (26.9)
	Franklin et al.	19 (43.2)	8 (18.2)	17 (38.6)
	Jirikowic	10 (40)	4 (16)	11 (44)
	Carr et al.	19 (61)	8 (26)	4 (12.5)

a Glenrose $N = 26$. b Franklin et al. $N = 44$. c Jirikowic (2003) $N = 26$. d Carr et al. $n = 31$