University of Alberta

Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder: Assessing Alternative Measures in Predicting Adaptive Behaviour

by

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Abstract

In this study of 38 children and adolescents with Fetal Alcohol Spectrum Disorder, the relations between measures of executive functioning (EF), intelligence and adaptive behaviour were explored. Applying Miyake et al.'s (2000) model, three areas of EF were assessed: working memory, set shifting, and inhibition. Relations were found between the WISC-IV, the Cognitive Assessment System (the two tests of intelligence employed in this study) and the three targeted areas of EF (as measured by tests from the Delis-Kaplan Executive Function System and the Working Memory Test Battery for Children). Consistent with findings of past research, global IQ composites were not predictive of adaptive behaviour as rated by parents or teachers. However, in predicting parent-rated adaptive behaviour, component scores derived from the CAS did account for unique variance beyond that explained by the WISC-IV full scale IQ and demographic variables. For teacher-rated adaptive behaviours, it appears that age, gender, and ethnicity were most predictive. Profile analysis of scores derived from the two IQ tests converged to suggest particular strengths in the area of nonverbal processing and particular weaknesses in the area of EF. Implications for policy, intervention, and future research are discussed.

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DEDICATION

I would like to dedicate this dissertation to my friend, Jordan, whose life has brought more richness to my own, and who has shown me the beauty that a person with FASD can have. I would also like to dedicate this work to all of the families of children with FASD who struggle to find support and services for themselves and for their children.

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CHAPTER I: INTRODUCTION

The effects of alcohol exposure on fetal development have become the focus of an increasing amount of research over the past several decades. A growing literature has developed to document the mechanisms through which alcohol might impact fetal development (Goodlett & Horn, 2001; Guerri, 1998; Schenker et al., 1990) and to establish the effects that alcohol can have on the neuroanatomical (Roebuck, Mattson, & Riley, 1998), cognitive (Kaemingk & Paquette, 1999), and behavioural/social outcomes of those exposed (Kelly, Day, & Streissguth, 2000). Converging evidence within this literature has helped to develop our understanding of the implications of prenatal alcohol exposure on exposed individuals, their families, and communities (Streissguth, 1997). Moreover, this research has contributed to the development of alternative means for preventing and diagnosing alcohol-related conditions (Funkhouser & Denniston, 1985; Grant, Ernst, & Streissguth, 1999; Hutson, 2006; Institute of Medicine, 1996; Streissguth, 1994, 2001), and for treating and supporting alcohol-exposed individuals (Burgess & Streissguth, 1992; Caley, Shipkey, Winkelman, Dunlap, & Rivera, 2006; Floyd, O'Connor, Bertrand, & Sokol, 2006; Grant et al., 2004; Kalberg & Buckley, 2007; Watson & Westby, 2003; Weiner & Morse, 1994; Zevenbergen & Ferraro, 2001). Despite these advances, there still remains a need for specific intervention strategies that address the related neurocognitive deficits of alcohol-exposed persons, such that the development of secondary disabilities can be prevented (Streissguth & O'Malley, 2000).

The complexities associated with prenatal alcohol exposure are apparent in the many names and terms used to describe and diagnose persons impacted by such exposure (Chudley et al., 2005). Fetal Alcohol Spectrum Disorder (FASD) is the newest and broadest term applied to individuals who have been alcohol-exposed. It encompasses various alcohol-related diagnostic categories and aims to capture the continuum of symptomatology associated with various alcohol-related diagnoses (Streissguth & O'Malley, 2000). Fetal Alcohol Syndrome (FAS) was the first term used to classify the pattern of effects associated with heavy prenatal alcohol exposure (Jones & Smith, 1973), and likely remains the most widely recognized of the alcohol-related terms. It is a medical diagnosis applied to individuals who have been prenatally exposed to alcohol and who evidence the requisite symptoms of central nervous system (CNS) neurodevelopmental abnormalities (i.e. decreased cranial size at birth; structural brain abnormalities; neurological hard or soft signs), growth retardation (i.e., low birth weight for gestational age; decelerating weight over time unrelated to nutrition; disproportionately low weight to height), and characteristic facial anomalies (i.e.short palpebral fissures and abnormalities in the premaxillary zone) (Institute of Medicine, 1996). Fetal Alcohol Effects (FAE) and other related terms (e.g., Alcohol Related Neurodevelopmental Disorder) were later used to describe individuals who had been exposed to alcohol prenatally but who evidenced only some of the symptoms of FAS (Clarren & Smith, 1978; Institute of Medicine, 1996).

CNS dysfunction is arguably the most devastating consequence of prenatal alcohol exposure (Streissguth, Sampson, & Barr, 1989). CNS abnormalities resulting from fetotoxic insult sometimes manifest in a complex pattern of behavioural and/or cognitive deficits that can include: "learning difficulties; deficits in school performance; poor impulse control; problems in social perception; deficits in higher level receptive and expressive language; poor capacity for abstraction or metacognition; specific deficits in mathematical skills; or problems in memory, attention or judgment" (Institute of Medicine, 1996, p. 77). Historically, traditional IQ tests, including those developed by Wechsler and Stanford-Binet, have been a primary means for measuring CNS deficits in persons with FASD (Mattson & Riley, 1998). IQ tests are frequently mandated at the level of public policy (Kranzler, 1997; Reschly, 1997; Ramey & Ramey, 2000), and decisions surrounding access to government supports are often based on scores derived from these measures. Performance on such tests has led to the understanding that alcohol exposure is the number one non-genetic cause of mental retardation in the Western world (Abel & Sokol, 1987). Although many individuals impacted by prenatal alcohol exposure display deficits in overall intellectual functioning as assessed by traditional IQ tests, many others achieve IQ scores within the average and above-average ranges (Kerns, Don, Mateer, & Streissguth, 1997; Mattson & Riley, 1998; Streissguth, Barr, Kogan, & Bookstein, 1996). What is troubling is that IQ scores often fail to accurately reflect the cognitive functioning of alcohol-exposed persons. That is, the predictive validity of IQ scores and the inference of a positive relationship between performance on IQ tests and real life success are unsupported by recent findings within FASD research. Many individuals with FASD experience significant cognitive deficits and challenges with adaptive behaviour that are unpredicted and unexplained by IQ (Mattson, Goodman, Caine, Delis, & Riley, 1999; Thomas, Kelly, Mattson, & Riley, 1998). In fact, recent research counter-intuitively suggests that individuals with FASD with IQ scores above 70 (the cut-off for a designation of mental retardation) may be at greater risk for developing a secondary disability than those with lower IQ scores (Streissguth et al., 1996). These secondary disabilities have implications for many areas of an affected person's life and include problems with independent living and employment, mental health problems, disrupted school experience, trouble with the law, confinement, inappropriate sexual behaviour, and alcohol/drug problems.

Secondary disabilities are not inevitable outcomes of prenatal exposure to alcohol. These disabilities can " presumably be ameliorated (either fully or partially) through better understanding and appropriate interventions" (Streissguth et al., 1996, p. 30). Despite this optimistic position and the notion that early intervention might protect against the development of secondary disabilities (Streissguth et al., 1996), many individuals with FASD are barred from accessing government services on the basis of IQ scores that are above the cut-off for eligibility (Kerns et al., 1997; Schonfeld, Mattson, Lang, Delis, & Riley, 2001). Policy that dictates the continued use of traditional IQ tests limits the likelihood of identifying certain individuals who might benefit from intervention and supports. Furthermore, even when individuals are identified as having a disability on the basis of their performance on traditional IQ tests, the limitations inherent in the properties of these tests restrict their usefulness in directing effective strategies for remediation (Das, 2002).

The failure of traditional IQ tests to adequately capture executive functioning (EF) (Ardila, Pineda, & Rosselli, 2000; Crinella & Yu, 2000; Duncan, Burgess, & Emslie, 1995) might explain why researchers continue to find the functional problems of persons with FASD to be greater than that predicted by full-scale IQ scores. EF is associated with the frontal lobe and has been described as "the ability to maintain an appropriate problem solving set for attainment of a future goal"(Welsh & Pennington, 1988, p.201). More specifically, EF encompasses cognitive abilities that include self-regulation, sequencing of behaviour, flexibility, response inhibition, planning, and organization of behaviour (Eslinger, 1996). Deficits in EF are prevalent among persons with FASD and are often unrelated or fully explained by diagnostic category or IQ scores (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000; Kerns et al., 1997; Mattson et al., 1999; Schonfeld et al., 2001). They are thought to underlie many of the day-to-day problems faced by persons with FASD, such as poor judgment, weak impulse control, and an inability to use feedback to alter behaviour (Connor, et al., 2000; Mattson et al., 1999).

Research in the area of FASD suggests that problems with adaptive functioning and maladaptive behaviours may be better explained as a result of deficits in EF than as a result of an overall lowering of intellectual ability (Kodituwakku, May, Clericuzio, & Weers, 2001). If there is a strong relation between EF, adaptive behaviours, and maladaptive behaviours, measurement systems that account for EF abilities may result in more accurate assessment and remediation for individuals with FASD-related diagnoses.

The PASS (Planning, Attention, Simultaneous and Successive) theory of intelligence and the Cognitive Assessment System (CAS; Naglieri & Das, 1997) based on this theory may be useful in the assessment of persons with FASD related diagnoses. The PASS theory was borne out of research in the areas of neuropsychology, cognitive psychology and information processing. Within this theory, intelligent behaviour is considered the result of the interdependent relations between three cognitive systems: planning, arousal, and simultaneous/successive processing (Das, 2002; Kirby & Das, 1990). The PASS theory recognizes the planning system as playing a central role in relation to the other cognitive systems (Jarman & Das, 1996). The planning system involves goal setting, strategy selection or construction, and performance monitoring and is aligned with EF abilities and the prefrontal cortex (Kirby & Das, 1990). In comparison to measures that focus solely on EF, the CAS, in measuring EF along with other relevant cognitive systems believed to be related to intelligent behaviour, should allow a more complete and accurate understanding of an examinee's cognitive profile. Based on its theoretical underpinnings and its inclusion of EF measures, the CAS offers promise in the assessment of individuals with FASD.

The proposed study explored three areas of EF—inhibition, set shifting, and working memory—in children and adolescents with confirmed FASD related diagnoses. The relations between EF and two tests of intelligence (WISC-IV and the CAS)—one traditional and one contemporary—were examined. Finally, the associations between EF, intelligence, and adaptive behaviour (Adaptive Behavior Assessment System- Second Edition) were investigated. It was hypothesized that the contemporary, multidimensional test of intelligence, relative to the traditional test of intelligence, would better capture EF deficits (as measured by a battery of EF tests), a particular area of weakness in alcohol-exposed persons. In measuring this relevant area of cognitive functioning, along with other important aspects of cognitive processing, it was also hypothesized that the CAS would better predict adaptive behaviour for this sample.

CHAPTER II: LITERATURE REVIEW

As background to the current study, this literature review begins by providing a detailed description of FASD in terms of related diagnostic classifications and CNS dysfunction associated with prenatal alcohol exposure. Research exploring the adaptive and maladaptive behaviours linked with alcohol exposure in uterus is then reviewed to establish how CNS abnormalities associated with prenatal alcohol exposure can manifest in persons with FASD. This is followed by a discussion of EF—an important area of cognitive processing, which appears to be particularly impacted by prenatal exposure to alcohol, and which may account, in part, for some of the adaptive, maladaptive and intellectual problems and limitations experienced by persons with FASD. The concept of general intelligence and the limitations of the application of traditional IQ tests (e.g., Wechsler scales) with alcohol-exposed persons are then reviewed. The highlighted research establishes the variability of IQ scores achieved by individuals with FASD and helps to dispel the common misunderstanding that all individuals with FASD have IQ scores within the intellectually disabled range. The lack of a strong correlation between EF and IQ is offered as one explanation to account for the limited predictive validity of IQ scores with many alcohol-exposed persons. The PASS theory of intelligence, which represents a multidimensional theory of intelligence that incorporates EF, is then presented as a possible alternative for better understanding the intellectual capabilities and limitations of persons with FASD and for better predicting the adaptive and maladaptive behaviours of this population. Profile analysis based on CAS component scores is suggested as one means for directing remediation for persons with FASD.

Fetal Alcohol Spectrum Disorder (FASD)

Diagnostic Classifications and FASD

Although an implicit understanding of the implications of alcohol exposure on fetal development has been recognized for some time, not until 1968 (Lemoine, Haronsseau, Borteyru, & Menuet, 1968) and later in 1973 (Jones & Smith) were the aggregate symptoms of prenatal alcohol exposure outlined and described. In 1973, Jones and Smith coined the term Fetal Alcohol Syndrome (FAS) bringing international attention to the teratogenic effects of alcohol on fetal development. Since then, FAS has been considered the most severe syndrome to result from prenatal exposure to alcohol. Fetal Alcohol Effects (FAE) was later coined to describe children and animals that revealed some, but not all, of the classic features of FAS (Clarren & Smith, 1978; Institute of Medicine, 1996). Although the term FAE is still used, the Institute of Medicine (1996) recommended that it be replaced with a more refined nomenclature. It proposed a five category classification system that has been employed extensively within this field of research. This system recognizes the following categories: FAS with confirmed maternal alcohol exposure; FAS without confirmed maternal alcohol exposure; Partial FAS with confirmed maternal alcohol exposure; Alcohol-related birth defects (ARBD); and Alcohol-related neurodevelopmental disorder (ARND). More recently, Astley and Clarren (1999, 2000) and later Astley (2004), through the Fetal Alcohol Syndrome Diagnostic and Prevention Network, introduced another classification system that allows for greater accuracy in quantification of characteristic features related to FASD. Based on this system, clinicians employ a 4-Digit Diagnostic Coding system that provides a means for rating the degree of prenatal alcohol impact across the areas of growth deficiency, FAS facial phenotype, central nervous system dysfunction, and gestational alcohol exposure. Developers of this system have identified a total of 22 unique clinical diagnostic categories under which the 256 possible 4-digit diagnostic codes might fall.

The umbrella term FASD was introduced to reflect the continuum of effects of prenatal alcohol exposure. This term subsumes various FASD-related diagnostic categories (e.g., FAS, FAE, ARND, partial FAS, atypical FAS, static encephalopathy alcohol exposed) (Streissguth & O'Malley, 2000), attesting to the array of effects that prenatal alcohol exposure can have on an individual, and to the complexities surrounding differential diagnosis (Chudley et al., 2005). The rationale for introducing yet another term surrounding prenatal alcohol exposure rests on recent findings where comparable symptomatologies have been observed in individuals with FAS and those with FAE or ARND diagnoses.

The distinctions between FAS and related diagnostic categories are often made on the basis of the presence or absence of the physical phenotype of FAS, most frequently facial dysmorphology. Facial malformations are often associated with malformations of the brain (DeMeyer, 1975) as appears to be the case for many individuals with FAS (Kotch & Sulik, 1992; Sulik, 2005). Although the facial gestalt associated with prenatal alcohol exposure has been the focus of a considerable amount of research (Astley & Clarren, 1996; Astley, Magnuson, Omnell, & Clarren, 1999; Moore et al., 2002; Sheller, Clarren, Astley, & Sampson, 1988; Sulik, Johnston, & Webb, 1981), recent thinking has led some to recognize the paradox of the FAS face and to question utility of the current face-based nomenclature (Streissguth & O'Malley, 2000). While on the one hand the

FAS face has helped to alert physicians to the syndrome and to identify those impacted by the syndrome, on the other hand, it has at times distracted us from the real insult that alcohol exposure has on the developing fetus—that being its effect on the central nervous system (CNS). More and more research suggests that alcohol exposed individuals without the characteristic facial features evidence neuroanatomical (Bookstein, Sampson, Streissguth, & Connor, 2001; Riley, Mattson, Sowell, Jernigan, Sobel, & Jones, 1995; Mattson et al., 1994), behavioural (Kelly, Day, & Streissguth, 2000; Streissguth et al., 1996) and cognitive deficits (Bookstein, Streissguth, Sampson, Connor, & Barr, 2002; Connor et al., 2000; Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995; Mattson, Riley, Gramling, Delis, & Jones, 1998; Schonfeld et al., 2001) comparable to those of individuals with "full-blown" FAS. Given that alcohol is teratogenic throughout pregnancy (Bonthius & West, 1990; West & Hamre, 1985) while the facial features develop in a very discrete period of time (day 7 in the mouse model) (Sulik et al., 1981), the similarities noted between individuals with FAS and FAE or ARND are not surprising. Streissguth and O'Malley (2000) address the quandary of the FAS face and the current alcohol related diagnostic categories as they state, "the problem with a face-based diagnosis is that it isn't the face that needs the services" (p. 178). What is needed is a focus on the CNS dysfunction and on intervention strategies that account for our current understandings of brain-based behaviours (Streissguth & O'Malley, 2000). New findings in this field of research will undoubtedly lead to a more accurate and useful system for categorizing the effects of prenatal alcohol exposure.

Central Nervous System Dysfunction (CNS) and FASD

Alcohol is an extremely potent teratogen that can seriously compromise healthy fetal development (Van Dyke, Bonthius, Bonthius, McBrien, & Dyken, 1996). The central nervous system is one area in which alcohol exerts its teratogenic effects. Although the physical characteristics associated with FASD are linked most closely with drinking during the first trimester of pregnancy (Abel, 1981), the central nervous system develops throughout gestation (Bonthius & West, 1990; West & Hamre, 1985) and as such is vulnerable to the effects of alcohol exposure for the duration of pregnancy (Rosett, Weiner, Lee, Zuckerman, Dooling, & Oppenheimer, 1983). Research has explored anatomical and behavioural correlates of animals and humans prenatally exposed to alcohol to establish the effects of alcohol on the fetus (Driscoll, Streissguth, & Riley, 1990; Guerri, 1998). The limitations of animal to human extrapolation, as well as difficulties surrounding the accuracy of clinical reports of drinking mothers potentially confound the relation between alcohol exposure and fetal brain development (Schenker et al., 1990). Despite these restrictions, 30 years of research in this area has begun to establish parts of the brain that are particularly vulnerable to prenatal alcohol exposure, as well as possible mechanisms through which alcohol affects brain development. Most recently, advances in technology in the field of neuroscience have allowed for new ways to explore quantification of neuroanatomic structures impacted by prenatal alcohol exposure (Bookstein et al., 2001; Spadoni, McGee, Fryer, & Riley, 2007).

Proposed Mechanisms for Alcohol Impact

Several mechanisms have been postulated to account for the specific symptoms of FASD (Goodlett & Horn, 2001; Guerri, 1998; Schenker et al., 1990). The sheer number of hypotheses that attempt to explain how ethanol affects the developing brain " reflect both the lack of knowledge of the actual process and the many effects of alcohol on the body" (Schenker et al., 1990, p. 636). Guerri (1998) attributes the difficulties of identifying the mechanisms through which ethanol affects brain development to "the complexity of the brain, the broad effects of ethanol acting on different cell types and developmental stages, and the interrelationship between the hormonal, neurochemical, and other systems involved in normal brain formation" (p.309). Furthermore, the potentially confounding influence of many variables that moderate the relation between alcohol exposure and fetal outcomes (e.g., maternal nutrition, maternal age, polydrug use, fetal susceptibility) (Abel, 1981; Rosett et al., 1983; Streissguth & Dehaene, 1993), make it difficult to establish the teratogenic impact of alcohol exposure on fetal development, and the means through which alcohol exerts its influence.

Alcohol enters the blood stream by means of absorption through the stomach and small intestine (Overholser, 1990). The placenta does not act as a barrier inhibiting transfer of alcohol from the mother to the fetus. Rather, alcohol is said to easily cross the placenta, reaching levels in the fetus similar to that of the drinking woman (Streissguth, Landesman-Dwyer, Martin, & Smith, 1980; Rose, Strandhoy, & Meis, 1981). Alcohol is generally thought to impact fetal development by means of its influence on cells, neurotransmitters, and hormones (Becker, Diaz-Granados, & Randall 1996; Guerri, 1998). Researchers have identified hypoxia/ischemia, the effects of alcohol on prostaglandins, protein synthesis, dysregulation of neurotrophic factors, cell membrane fluidity, and free radical damage as some of the probable etiological factors involved in the teratogenic actions of alcohol on the fetus (Guerri, 1998; Hannigan, 1996; Schenker et al., 1996).

In an attempt to explicate the possible mechanisms of ethanol-induced neurological damage, Guerri (1998) proposed a path model. This model accounts for findings from research that implicates neurotrophins and other trophic factors and their receptors in neural survival and synaptic plasticity in normal brain development. Based on this model, the indirect effects of ethanol exposure might explain reduced blood flow to the fetus, free radical generation, and maternal malnutrition, all of which might lead to cell membrane damage, interference in protein synthesis and alterations in DNA. Guerri distinguishes this from the direct effects of ethanol on neurons and glial cell functions. The model indicates how *low* ethanol exposure can directly affect neurons and lead to functional and behavioural deficits. In comparison, *high* ethanol exposure is thought to lead to more structural brain alterations and severe CNS dysfunction.

Structural Damage and Behavioural Correlates Associated with Alcohol Exposure

Neuroanatomical and electrophysiological evidence has accumulated to establish the modularity of the neurotoxic effects of alcohol exposure on brain development (Roebuck et al., 1998). These findings, coupled with advances in the study of neuropsychology that relate cognitive functions with distinct physical regions of the brain (Cummings, 1993; Golman-Rakic, 1993; Salmon, Heindel & Hamilton, 2001), have allowed us to better understand the physiological basis of many cognitive and behavioural deficits of individuals with FASD (Bookstein, Streissguth, Sampson, Connor, & Barr, 2002; O'Hare et al., 2005). The behavioural sequelae typical of individuals with FASD are, for the most part, congruent with what would be expected given the functions of brain regions vulnerable to fetal alcohol damage (Guerri, 1998).

The teratogenic actions of alcohol exposure sometimes result in global damage to the brain and an overall decrease in size. Both individuals with FAS and FAE have been found to evidence microcephaly where head circumference measures at least two standard deviations below the mean (Clarren, Alvord, Sumi, Streissguth, & Smith, 1978; Jones & Smith, 1975; Roebuck et al., 1998; Wisniewski, Damska, Sher, & Qazi, 1983). This condition is generally correlated with large volumes of maternal alcohol consumption (Clarren et al., 1978) and often results in significant limitations in intellectual functioning.

Fetotoxic insult is also associated with direct damage to particular regions of the brain. The corpus callosum, basal ganglia (through its role in the dorsolateral prefrontal circuit), and frontal lobes are structures that are vulnerable to fetal alcohol damage and that appear to be involved in EF abilities. Findings from several studies reveal agenesis or dysgenesis of the corpus callosum as a consequence of prenatal exposure to alcohol (Bookstein et al., 2007; Clark, Li, Conry, Conry, & Loock, 2000; Clarren & Smith, 1978; Riley et al., 1995; Swayze et al., 1997;Wisniewski et al., 1983). Bookstein, Sampson, Streissguth, and Connor (2001) found a relation between callosal shape and unique behavioural correlates in alcohol exposed individuals. A thick callosum was associated with deficits in executive functioning, while a thin callosum was associated with a deficit in motor function (Bookstein et al., 2002). Interestingly, the excess shape variation associated with either profile appeared to be unrelated to full-scale IQ or to the distinction between FAS and FAE (Bookstein et al., 2002).

The basal ganglia are also vulnerable to alcohol damage (Mattson et al., 1994; Mattson et al., 1996). The basal ganglia have long been recognized as vital in the execution and maintenance of motor behaviour (Martin, 1998), but have been more recently connected with cognitive function unrelated to movement (Cote & Crutcher, 1991). As parts of the basal ganglia (i.e., caudate nucleus, globus pallidus) are involved in the dorsolateral prefrontal circuit (Cummings, 1993), lesions of the basal ganglia might account for EF deficits observed in alcohol-exposed persons such as those related to goal-directed behaviours and changing behavioural set (Mattson et al., 1994).

Damage to the frontal lobes as a consequence of fetal alcohol exposure has recently been documented. Cell loss in the medial prefrontal cortex of alcohol exposed rats (Mihalick, Crandall, Langlois, Krienke, & Dube, 2001), decreased levels of complexin proteins in the frontal cortex of alcohol exposed rats (Barr, Hofmann, Phillips, Weinberg, & Honer, 2005), morphological abnormalities in the frontal lobe of children with FASD (Sowell et al., 2002), increased blood flow to the right frontal region of children with FAS (Riikonen, Salonen, Partanen, & Verho, 1999), abnormal cortical thickness in the right frontal regions of individuals with heavy prenatal alcohol exposure (Sowell, Mattson, Kan, Thompson, Riley, & Toga, 2007), and reduced frontal lobe size in fetuses exposed to alcohol prenatally (Wass, Persutte, & Hobbins, 2001) suggest that prenatal alcohol exposure directly impacts the frontal lobes.

Cortical lesions in the dorsolateral prefrontal circuit, as with damage to the frontal lobes, can result in EF-related neuropsychological deficits including decreased verbal and design fluency, impaired set shifting, and poor problem solving (Cummings, 1993, p.

877). Deficits such as these have been observed in persons with FASD (Kerns et al., 1997; Kodituwakku et al., 1995; Schonfeld et al., 2001).

In light of the modular impact of alcohol on brain structures associated with EF (Kodituwakku, Kalberg, & May, 2001), it appears that EF may represent a very relevant area of study for persons with FASD. Executive functioning deficits are thought to underlie many of the adaptive and maladaptive problems experienced by individuals with FASD (Bookstein et al., 2002; Kodituwakku et al., 1995; Mattson et al., 1999). The following section reviews findings central to adaptive and maladaptive functioning of animals and persons impacted by prenatal alcohol exposure.

Adaptive Behaviour and FASD

Adaptive behaviour is defined by the American Association on Mental Retardation (2002) as "the collection of conceptual, social, and practical skills that have been learned by people in order to function in their everyday lives" (p.14). Conceptual skills are described specifically as those related to cognitive, communication, and academic skills, examples of which might include reading, writing, and money concepts. Social skills are related to social competence as reflected in an individual's level of interpersonal skills, and for example, his/her ability to follow rules and obey laws. Finally, practical skills relate to independent living skills and may be evidenced in a person's occupational skills, and his/her activities of daily living such as meal preparation, self-care, and money management. Deficits in adaptive behaviour are thought to compromise an individual's ability to successfully adapt to life changes and environmental demands, and to perform activities necessary for personal and social sufficiency (American Association of Mental Retardation, 2002; Harrison, 1987; Sattler, 1992).

Problems with adaptive behaviours are associated with prenatal exposure to alcohol. In particular, there appears to be a strong relation between alcohol exposure and social functioning of those exposed (Carmichael Olson, Feldman, Streissguth, Sampson, & Bookstein, 1998; Schonfeld, Paley, Frankel, & O'Connor, 2006; Streissguth et al., 1991; Thomas, Kelly, Mattson, & Riley, 1998; Whaley, O'Connor & Gunderson, 2001). Findings from animal and human studies converge to suggest the adverse impact of prenatal alcohol exposure on social behaviour (Kelly, Day, & Streissguth, 2000). While studies conducted on animals have helped to determine the causal relation between alcohol exposure and aberrant social behaviours (Lugo, Marino, Cronise, & Kelly, 2003), studies on humans have begun to establish how social deficits can manifest in individuals prenatally exposed to alcohol (Thomas et al., 1998; Whaley et al., 2001).

To explore the adaptive and maladaptive behaviours of alcohol exposed persons, various measures including the Vineland Adaptive Behavior Scale (VABS; Sparrow, Balla, & Cicchetti, 1984) (Coles et al., 1991; Thomas et al., 1998; Streissguth et al., 1991; Whaley et al., 2001) the Child Behavior Checklist – 4/18 (Achenbach, 1991) (Carmichael Olson et al., 1997; Carmichael Olson et al., 1998; Brown et al., 1991; Nash et al., 2006) the Personality Inventory for Children (PIC; Wirt, Lachar, Klinedinst, & Seat, 1984) (Roebuck, Mattson & Riley, 1999), and the Social Skills Rating System (SSRS; Gresham & Elliott, 1990) (Schonfeld et al., 2006) have been employed. The VABS is a widely used measure of adaptive behaviours that has provided information regarding the social skills, communication skills, and living skills of persons with FASD

(Carmichael Olson et al., 1998; Coles et al., 1991; Streissguth et al., 1991; Thomas et al., 1998; Whaley et al., 2001). Findings from FASD studies generally indicate compromised abilities across areas of social, communication, and daily living skills (Streissguth et al., 1991; Thomas et al., 1998; Whaley et al., 2001). The social skills domain appears to be a particular area of weakness, as alcohol-exposed persons tend to achieve the lowest scores on this domain relative to other domains of functioning (Carmichael Olson et al., 1998; Streissguth et al., 1991; Whaley et al., 2001). Based on results from their own study and those from previous studies (Streissguth et al., 1991; Thomas et al., 1998), Whaley et al. (2001) suggested that deficits in social competence may become more pronounced with age, and that social deficits may be arrested at the level of 6-year-old. Social delays for persons with FASD are evident in those without intellectual disabilities (as determined by traditional IQ tests), and are not attributed to deficits in IQ (Carmichael Olson et al., 1998; Thomas et al., 1998; Whaley et al., 2001). Despite the fact that most FASD studies suggest specific and overall adaptive deficits, some studies present divergent findings, where alcohol-exposed children and adolescents do not evidence adaptive limitations (see Coles et al., 1991; Howell, Lynch, Platzman, Smith, & Coles, 2006).

Maladaptive Behaviour and FASD

In contrast to adaptive behaviours that represent competencies associated with successful adaptation, maladaptive behaviours are more closely associated with behavioural problems that can interfere with successful adaptation to one's environment. Maladaptive behaviours are common among individuals with FASD (Clark, Lutke, Minnes, & Ouellette-Kuntz, 2004; Streissguth et al., 1996; Streissguth et al., 2004). Although different in expression, maladaptive behaviours are present across the life span for many individuals who have been prenatally exposed to alcohol (O'Connor & Paley, 2006; Steinhausen, Willms, & Spohr, 1993, 1994; Steinhausen & Spohr, 1998; Steinhausen, Willms, Metzke, & Spohr, 2003; Streissguth et al., 1996). Mental health problems and conduct problems are often addressed areas of maladaptive functioning for this population. In fact, mental health problems are the most frequently reported secondary disability associated with prenatal exposure to alcohol (Clark et al., 2004; Streissguth et al., 1996). Depression, suicide threats and attempts, panic attacks, psychosis, and drug and alcohol dependence are commonly reported mental health problems affecting many individuals with FASD (Clark et al., 2004; Streissguth et al., 1996; Roebuck et al., 1998; Steinhausen et al. , 1994). New research suggests that prenatal alcohol exposure acts as a significant risk factor for the development of depressive symptomatology even in young children (O'Connor & Paley, 2006). Mental health problems are present for individuals with and without the facial dysmorphology associated with FAS, including those without an intellectual disability (Clark et al., 2004; Streissguth et al., 2004).

Conduct-related problems as a form of maladaptive behaviour are also typical of individuals with FASD (Carmichael Olson et al., 1997; Clark et al., 2004; Roebuck et al., 1999; Streissguth et al., 1991); however, not all studies find rates of conduct problems to be higher in children with reported prenatal alcohol exposure (Howell et al., 2006). Parents of alcohol-exposed children often report behavioural problems including bursts of aggression and lack of impulse control (Aronson & Hagberg, 1998; Gardner, 2000; Steinhausen & Spohr, 1998). In a recent Canadian study exploring the behavioural phenotype of children and adolescents with FASD, researchers found parent reports on

12 items from the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) that target conduct related problems, to effectively discriminate between individuals with FASD from those with ADHD or controls (Nash et al., 2006). Conduct related problems might sometimes result in incarceration and trouble with the law (Mattson et al., 1999). Reports of alcohol affected individuals and their caretakers (Clark et al., 2004; Streissguth et al., 1996; Streissguth et al., 2004), as well as research conducted within correctional facilities (Fast, Conry, & Loock, 1999), indicate high rates of incarceration and trouble with the law often leading to a disproportionate representation of alcohol affected individuals in the criminal justice system. Problems with children's adaptive and maladaptive behaviours have been linked with higher levels of reported parental stress (Paley, O'Connor, Frankel, & Marquardt, 2006).

Although cognitive limitations, as assessed by traditional IQ tests, are often associated with deficits in adaptive behaviours and with maladaptive behaviours (Liss et al., 2001; Steinhausen et al., 1993; Vig & Jedrysek, 1995), it appears that IQ scores do not adequately explain the adaptive and maladaptive problems experienced by persons with FASD (Clark et al., 2004; Carmichael Olson et al., 1998; Streissguth et al., 1996; Streissguth et al., 2004; Thomas et al., 1998; Whaley et al., 2001). There is some suggestion that deficits in EF may account for problems with adaptive skills and maladaptive behaviours (Connor et al., 2000; Kodituwakku, May, et al., 2001; Mattson et al., 1999). In a recent study exploring this association, Schonfeld et al. (2006) found parent-reported levels of children's EF abilities to account for a small, but significant, amount of the variance in children's rated social skills, an area of adaptive behaviour. If a relation between these constructs exists, this may point to a direction for more accurate assessment of alcohol-exposed persons. The following section reviews current understandings of EF, alternative models of EF and findings in FASD research specific to EF.

Executive Functioning and FASD

Definitions of Executive Functioning (EF)

There is a great deal of academic debate surrounding what constitutes executive functioning (EF)—what tasks should fall under the umbrella of EF, and which processes can account for successful performance on what have been identified as EF tasks. EF is involved in novel problem solving tasks (Sbordone, 2000), where planning, strategy application, impulse control and organized search are thought to aid in future-oriented behaviour (Welsh, Pennington, & Groisser, 1991). Although there may exist some agreed upon aspects of EF, a universal definition of EF does not exist (Eslinger, 1996). Some theorists warn against the tendency to exalt EF and the "higher order" processes that it has become associated with (Denckla, 1996; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Denckla (1996) states, "it may be argued that few problems or controversies would exist with respect to EF constructs if stricter adherence to their output-related or motor-affiliative aspects were emphasized to the exclusion of some of the more elusive and 'exalted' constructs that have come to inhabit the space under the EF umbrella" (p. 265). The disagreement of what control processes are associated with EF and the breadth of activities that currently fall under the domain of EF have contributed to the complexity of research in this area and the overlap of EF with other constructs such as attention and memory (Delis, Kaplan, Kramer, 2001a; Denckla, 1996).

Models of EF and FASD

There are numerous models and theories proposed to account for the nature, structure and activities of EF (Borkowski & Burke, 1996). The diversity of these theories and models reflects the current lack of agreement as to what constitutes EF. Furthermore, it demonstrates the conflicting perspectives on how constructs of EF should be validated. While some argue for theory driven assessment of constructs of EF (Barkley, 1997, 2001), others defend their failure to derive theory-based instruments on the grounds that tenuous understandings of the frontal lobe fail to provide strong theoretical frameworks on which to base clinical tests (Delis et al., 2001a). Despite the availability of alternative models of EF and the potential benefit of their application, very few studies of FASD-affected persons have made use of these models. The following section reviews two models of executive functioning and their potential use in better understanding EF deficits in alcohol-exposed persons. The Norman and Shallice (1980) model was chosen because of its relevance in better understanding the Planning component of the PASS theory. Both the Norman and Shallice model and the PASS theory of intelligence have been influenced by the work of A.R. Luria (1966, 1973), whose work will be described in more detail in the following sections. The Norman and Shallice model was also influenced by work in the area of artificial intelligence (Shallice, 2002), and offers a theoretical explanation to account for successful performance on different EF tasks. The Miyake et al.'s (2000) model of EF was chosen as it provides a means for operationalizing EF and for identifying related but separate dimensions of EF, the existence of which have been supported by empirical research (Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Pennington, 1997).

Norman and Shallice's Supervisory Attentional System

Norman and Shallice (1980) developed an information-processing model to account for the role of attention in action. Although the Supervisory Attentional System (SAS) was originally constructed as a model of attentional control of action, the role of the SAS has been equated with executive control (Miyake et al., 2000), and is thus relevant as a means of accounting for 'dysexecutive' behaviours. Norman and Shallice attempted to explain how activities are controlled, and why this control sometimes falters "leading to errors which range from the trivial inadvertent eating of a chocolate when one did not intend to, to the disastrous loss of control of a nuclear power plant" (Baddeley, 1990, p. 125). This theory draws upon findings from A.R. Luria, a Russian neuropsychologist who, based on clinical and experimental samples of normal and brain-injured subjects, divided the brain into three areas, each considered responsible for unique functions (Luria, 1966, 1973). Luria's subjects evidenced specific impairments consistently found as a result of insult to particular regions of the brain. In an attempt to provide a foundation for Luria's findings on frontal functions (Shallice, 1988, p. 332), Norman and Shallice proposed a theoretical framework to specify the specific functions and relations of different cognitive processes called upon when a performance is automatic and when it is under deliberate conscious control (Norman & Shallice, 1980; Shallice, 1988).

At the most basic level of this theoretical framework are thought or action schemata that involve a particular pattern of demands that will be selected in well-defined circumstances and when a sufficient level of activation exceeds a given threshold (Norman & Shallice, 1980). While contention scheduling is proposed as the mechanism that activates and inhibits supporting and conflicting schemas in automatic or overlearned behaviours, the SAS is implicated in those instances when an existing set of schema does not exist to achieve control of a desired behaviour. Because contention scheduling fails to explain all levels of the selection of thought and action operations, the SAS has been introduced as that mechanism "which modulates rather than dictates the operation of the rest of the system" (Shallice, 1988, p. 332) and which accounts for the qualitatively different process in non-routine selection of action. In all cases of deliberate action, but particularly when a task is novel or complex, the SAS provides a source of control upon the selection of schemas by means of exerting extra activation or inhibition to influence the selection of the contention scheduling mechanism.

Shallice (1988) relates the SAS to Luria's system for the programming, regulation, and verification of activity. The higher level cognitive control attributed to the SAS corresponds to prefrontal regions of the brain. Failures in the SAS have been implicated in gross impairments in individuals' abilities to perform tasks that require error correction or planning, or those that are in some way novel (Norman & Shallice, 1980). Consistent with failures of the SAS are deficits observed in the so-called frontal syndrome (Shallice & Burgess, 1991). There is some indication that the SAS may also account for deficits in individuals with FASD (Kodituwakku et al., 1995).

Based on the conceptual framework provided by the Norman-Shallice model, Kodituwakku et al. (1995) assessed alcohol-exposed individuals (aged 9 to 18 years) using neuropsychological assessment tools selected for the purpose of measuring planning (The Progressive Planning Test), regulation of behaviour (delayed response tasks, the Controlled Oral Word Assocation Test, and the Subject-Ordered Task) and verification or utilization of feedback (Wisconsin Card Sorting Test (WCST), Competing Motor Programs). Although differences between the alcohol-exposed group and controls were not found on the delayed response tasks, category fluency task or competing motor tasks, alcohol-exposed participants performed significantly worse than controls on the planning task and the WCST. Planning and cognitive flexibility deficits observed in alcohol-exposed children in this study led researchers to conclude that higher order cognitive deficits might be a function of the failures of the SAS.

The Norman and Shallice model might help to elucidate what underlies EF deficits in persons with FASD. Although developers of this model offer little direction as to what constitutes an adequate measure(s) of the SAS, this theoretical model, in explicating the chain of events that lead to successful executive functioning, provides some indication of what elements are necessary in order that a task be considered a measure of EF.

Miyake et al.'s (2000) Model of Executive Functioning

Miyake et al.'s (2000) model of EF is not necessarily incongruent with the Norman-Shallice model of EF. In fact, it could be argued that Miyake et al. provide a means for measuring the SAS, or some aspects of the SAS. While Norman and Shallice provide an information processing account of the nature of EF, Miyake et al. (2000) provide a way to operationalize EF. Insofar as the tasks identified by Miyake et al. (2000) relate to the programming, regulation, and verification of behaviour implicated in the Norman-Shallice model, these models may actually complement one another. Miyake et al. (2000) attempted to gain an empirical basis for theory development, and identified three latent variable executive functions including mental set shifting ("shifting"), information updating and monitoring of the working memory representations ("updating"), and inhibition of prepotent responses ("inhibition") to determine whether they represented a unitary construct of EF or separable aspects of EF. These researchers used nine relatively pure EF tasks, each task presumed to capture one of the three target executive functions (i.e. shifting, updating, or inhibition). Using confirmatory factor analysis it was established that while a moderate relation existed between manifest variables that contributed to shifting, updating, and inhibition, a three-factor model as opposed to a one-factor model, best fit this data. Findings from this study of 137 college students were also seen to affirm these researchers' hypothesis that shifting, updating, and inhibition differentially affect performance on more complex EF tasks such as the WCST and the Tower of Hanoi, where, for example, WCST was most strongly related to shifting and TOH was most strongly related to inhibition. These findings are consistent with those of Pennington (1997), Lehto et al. (2003) and Friedman et al. (2006) who also identified three distinguishable dimensions of EF, including set shifting, working memory (related to Miyake et al's "updating") and inhibition.

The three processes identified by Miyake et al. (2000) may relate to the SAS. The SAS could be broken down simply into schema activation, schema selection, and schema stopping or shifting. Attentional processes, not specifically identified by Miyake et al. (2000), appear to be necessary in order that a stimulus situation produce a strong, trigger-schema activation (Shallice, 1988, p. 339). Working memory and inhibition would most likely be involved at the level of schema selection, and set shifting would be most relevant at the phase of schema stopping or shifting, where a schema is actively switched off in order that a more highly activated schema be selected.

To date, there have been no reported FASD studies that have used the Miyake et al. (2000) model. However, several studies in the area of FASD have employed measures aligned with EF processes of inhibition (Bookstein et al., 2002; Connor et al., 2000; Kodituwakku et al. 1995; Mattson et al., 1999; Noland et al., 2003; Rasmussen & Bisanz, 2005, October), updating/working memory (Burden, Jacobson, Sokol, & Jacobson, 2005; Carmichael et al., 1998; Connor et al., 2000; Kerns et al., 1997; Rasmussen, 2006; Streissguth et al., 1994), and set shifting (Bookstein et al., 2002; Connor et al., 2000; Carmichael Olson et al., 1998; Coles et al., 1997; Connor et al., 2000; Kerns et al., 1997; Kodituwakku et al., 1995; Mattson et al., 1999; Rasmussen & Bisanz, 2005, October; Schonfeld et al., 2001). Few studies in the area of FASD research have provided a comprehensive assessment of EF in alcohol-exposed participants for which tasks assess the range of EF processes identified by Miyake et al. (2000). For the most part, data obtained on executive functioning of individuals with FASD has accumulated from discrete studies that do not necessarily present their findings within the context of EF (Mattson et al., 1999). Even in those studies that have involved a comprehensive battery of EF tasks that might concurrently assess different aspects of EF (Bookstein et al., 2002; Connor et al., 2000; Rasmussen & Bisanz, 2005, October), the statistical procedures necessary to determine the nature of the relations between EF tasks and whether they contribute to a latent EF variable have not been conducted.

More recently, several FASD studies have employed the Behavior Rating Inventory of Executive Functioning (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000), a comprehensive parent and teacher report of children's executive functioning abilities (Rasmussen, Horne, & Witol, 2006; Schonfeld et al., 2006). This particular assessment tool, while not assessing EF directly, offers a measure of what parents and/or teachers observe of their child (student) across various EF domains (i.e., inhibition, set shifting, emotional control, working memory, plan/organize, organization of materials, and monitoring skills). In one study, findings suggested that across BRIEF domains, greatest weaknesses were found in the areas of working memory and plan/organize (i.e., ability to manage current and future oriented task demands), while children's relative strengths were observed in the areas of organization of materials (i.e., orderliness of work, play and storage areas) and shifting (Rasmussen, Horne, & Witol, 2006). In contrast, teacher reports did not reveal differences between BRIEF domains.

The WCST, identified by Miyake et al. (2000) as a complex EF task related to set shifting, has been used in the assessment of individuals with FASD and it appears that individuals with FASD have particular difficulties with the test (Carmichael Olson et al., 1998; Coles et al., 1997; Connor et al., 2000; Kodituwakku et al., 1995; Kodituwakku, May, et al., 2001). In the WCST, an examinee is called upon to organize cards on the basis of a rule necessary for successful completion of the task. Throughout the course of the task, six different rules are given to examinees. Shallice, according to Baddeley (1990), explains the failure to comply with a new rule as a failure of the SAS in allowing for the selection of a more appropriate schema. The failure of the SAS to accurately guide behaviour in accordance with a new rule can result in perseverative behaviour, whereby an examinee continues to act on the original rule (Shallice, 1988). Similar to findings from individuals with frontal lobe damage (Baddeley, 1990), researchers have identified a tendency for examinees with FASD to make perseverative errors on this task, failing to shift response set when a new rule is given (Kodituwakku et al., 1995; Kodituwakku, May, et al., 2001). Carmichael Olson et al. (1998) noted in their sample of nine nonretarded adolescents with FAS, that relative to controls, participants tended to make more disorganized and unplanned non-rule based error responses. Connor et al. (2000), using the WCST, found that examinees performed worse than was expected based on their regression-based predicted EF scores (calculated on the basis of the relation between IQ and EF for the pooled comparison group). Given these results, researchers concluded that alcohol has a direct effect on this aspect of EF, not mediated by IQ.

Miyake et al. (2000) also identified the Tower of Hanoi as a complex EF task. This task and similar tasks (e.g., Tower of London, Progressive Planning Test, D-KEFS Tower Test) are variably related to inhibition (Goel & Grafman, 1995; Miyake et al., 2000) and planning (Keil & Kaszniak, 2002; Norman & Shallice, 1980; Pennington, 1997) and have also been used in the assessment of persons with FASD (Kodituwakku et al., 1995; Korkman, Kettunen, & Autti-Ramo, 2003; Mattson et al., 1999; Rasmussen & Bisanz, 2005, October). Tower tasks generally require examinees to transfer rings of various colours and/or size, in as few moves as possible, from a starting peg to a goal position, while adhering to specific rules. Relative to controls, individuals with FASD have been found to perform poorly on various tower related tasks including the Progressive Planning Test (Kodituwakku et al., 1995) and the Tower of California (Mattson et al., 1999). Korkman et al. (2003), employing the Tower subtest within the NEPSY battery, also found alcohol-exposed adolescents to obtain "relatively poor scores" (p. 121) on this subtest, however significance levels were not reported. Divergent from these findings were those of Rasmussen and Bisanz (2005, October) where performance on the D-KEFS Tower Test, of a sample of 8- to 16-year-olds with FASD, did not differ from the normative mean.

Miyake et al.'s (2000) model may offer the potential for a deeper understanding of the EF deficits of persons with FASD. It is possible that prenatal alcohol exposure negatively impacts performance on some aspects of EF more so than others. If such were the case, then remediation that targets EF for this population should differentially address these aspects of EF. Identifying different aspects of EF may be helpful in determining which, if any, dimensions of EF are better captured by a particular measure of cognitive processing (Friedman et al., 2006). Furthermore, the Miyake et al. (2000) model may offer guidance as to what EF tasks should be chosen when assessing cognitive processes aligned with EF. While a comprehensive battery of EF tasks might assess a range of EF abilities, it is important to ensure that the currently identified dimensions of EF are adequately represented within a given battery.

Methodological limitations inherent in EF research and specific to FASD research might be addressed by applying EF models such as those described. The application of these models might also help to explain why traditional IQ tests have historically failed to adequately capture EF. The following section reviews literature central to the history of intelligence testing and to the focus on general intelligence. The foundation of the unidimensional conception of intelligence and the construction of traditional IQ tests provide some explanation to account for the failures of these tests in accurately assessing the range of cognitive abilities associated with intelligent behaviour.

Intelligence Testing and FASD

Much of the controversy in the study of intelligence centers on the concept of general intelligence (*g*), whether it exists, and whether it adequately captures the range of cognitive abilities associated with intelligent behaviour (Das, 1992; Gardner, 1983; Sternberg, 1985). General intelligence is considered a very general mental ability to reason, plan, solve problems and think abstractly (Gottfredson, 1997) and is thought to account for a person's tendency to perform relatively well or relatively poorly on a range of different tasks (Duncan, Emslie, & Williams, 1996). This construct derives from the statistical procedure of factor analysis and developed from Spearman's finding of the positive manifold of tests (Brody, 2000), where different tests of ability tend to correlate positively, resulting in a one-dimensional model.

Theorists have historically been divided on whether intelligence can be attributed to a general-factor (general unitary function) or a multiple-factor model (composite of several semi-independent abilities; Sattler, 1992). Traditional tests of intelligence, the first example of which came from the Binet-Simon scale of intelligence, are anchored by the general factor model (Boake, 2002). Like traditional tests that were later developed, the Binet-Simon scales were originally based on the understanding that scores on individual subtests were meaningful only in terms of their contribution to a composite, full scale score (Boake, 2002). In that a very general mental ability (as opposed to specific abilities) is thought to underlie performance across a range of subtests, developers of traditional tests of intelligence tend to minimize the importance of information gathered by means of isolated tests of ability. This thinking is counter to new understandings in the area of cognition and to several contemporary theories that attempt to delineate the underlying structure of intelligence, identifying distinct aspects of this construct (Das, 2002). Contemporary tests of intelligence, most of which strive to link theory and practice (Naglieri & Das, 1997), recognize differentiated cognitive functioning, and attempt to capture this differentiation by means of theoretically based tests of intelligence. Contemporary theories of intelligence are most often operationalized using batteries of tests that are compiled to measure and interpret an individual's cognitive profile. Unlike traditional tests that focus primarily on a composite score considered reflective of a general mental ability, multidimensional contemporary tests of intelligence incorporate subtests for the purpose of measuring strengths and weaknesses across meaningful cognitive domains (Naglieri, 2000).

FASD and Traditional Tests of Intelligence

The majority of studies that explore the intellectual functioning of persons with FASD employ traditional tests of intelligence including the Wechsler scales and the Stanford-Binet scales of intelligence (Mattson & Riley, 1998). Based on scores derived from such measures, Mattson and Riley (1998), in reviewing the available FASD literature, found the mean IQ of persons with FAS to be 65.73 ($SD = 20.2$), with scores ranging from a low of 20 to a high of 120. Streissguth et al. (1996; 2004), in a large-scale study of persons ranging in age from 3 to 51 years, with FAS and FAE, also found extreme variability in IQ scores (based on WISC, WAIS, and other unidentified tests). Within Streissguth et al.'s (2004) study, the 138 participants with FAS achieved a mean IQ of 80. This was compared to the 221 individuals with a diagnosis of FAE who achieved a mean IQ of 88.

Profile analysis of subtest and scaled scores from IQ tests has been used as a method to determine whether a pattern of intraindividual strengths and weaknesses exists for persons with FASD. A pattern, if present for many individuals with a similar diagnosis, can help to discriminate those with or without a certain disorder. Furthermore, such a pattern can aid in developing hypotheses about an individual's learning and abilities, which can ultimately enhance the usefulness of recommendations for treatment, educational interventions, or vocational placements (Sattler, 1992). While profile analysis has been advocated, past research has not established the utility of this practice with Wechsler scales (Sattler, 1992). The limitations of this method are apparent for individuals with FASD, where findings from past studies do not converge to indicate a reliable strength or weakness pattern for persons with FASD. Although several studies have found significant differences between Verbal IQ and Performance IQ for persons with FASD (Rasmussen, Horne, & Witol, 2006; Streissguth et al., 1996), this pattern is not consistent, and based on the extant literature, findings remain equivocal (Mattson & Riley, 1998). Given that Wechsler subtests and scales were not designed to necessarily measure unique processes, findings such as these are not unexpected (Naglieri, 1999; Sattler, 1992).

The failure of traditional IQ tests to adequately capture EF (Das, 2002; Pennington & Ozonoff, 1996) may account, in part, for why researchers have yet to find a reliable pattern of weakness for persons with FASD. EF deficits are common in persons with FASD and are unexplained by overall lowered intelligence.

Relation Between EF and IQ

Despite FASD researchers' tendency to want to explain EF as a function of IQ (Connor, et al., 2000), there is little evidence to support a causal relation between these constructs. As is often the case with individuals with frontal lobe damage (Crinella & Yu, 2000), there appears to be a discord between EF abilities and IQ scores for persons with FASD. Many of the studies that assess EF abilities in alcohol-exposed individuals, choose participants with IQ scores above the standard cutoff for a diagnosis of intellectual disability (70-75), thus allowing for an assessment of EF deficits in "higher functioning" persons (Kerns et al., 1997; Mattson et al., 1999; Schonfeld et al., 2001). Findings from these studies suggest that EF impairments cannot be fully explained by a general lowering of intellectual functioning as assessed by traditional IQ tests (Kerns et al., 1997; Mattson et al., 1999; Carmichael Olson et al., 1998; Schonfeld et al., 2001). Various techniques have been employed to assess the relations between EF and IQ for persons with FASD. The use of comparison or control groups as a way to estimate expected EF scores given certain IQ scores is one method that has been employed in a few studies (Connor et al., 2000; Kerns et al., 1997). For example, Connor et al. (2000) measured the difference between alcohol-exposed participants' observed EF scores and their regression-based predicted EF scores (based on the relation between IQ and EF for the pooled comparison group). This method was used to determine a direct or indirect (via the mediating function of IQ) impact of alcohol on EF. A direct effect of prenatal alcohol damage on EF was inferred when individuals with FASD performed worse than expected on the EF measures given the IQ-adjusted scores. Conversely, an indirect effect was inferred when there was an equal distribution of those that did better and those that did worse than expected on the EF measures given the IQ-adjusted scores. Based on their findings, these researchers suggest that certain EF tasks are particularly sensitive to the direct effects of prenatal alcohol exposure.

Although Connor et al.'s (2000) study offers some indication of EF measures that might be particularly useful in the assessment of persons with FASD, the assumption that IQ mediates the relation between alcohol damage and EF deficits may be misguided. When IQ does not predict EF, the logical assumption should not be that this was an effect of general intelligence on EF. The point that these authors do not make is that traditional IQ tests may simply fail to assess certain aspects of EF, and thus remain unrelated to scores from certain EF tests (Kirby & Das, 1990).

Other studies have used correlation and regression analysis to explore the relations between IQ and EF for persons with FASD. Mattson et al. (1999) found no relation between full-scale IQ scores and EF tests aligned with planning, inhibition, abstract thinking and flexibility. Similarly, using Pearson's correlations, Schonfeld et al. (2001) did not find relations between full scale IQ, verbal IQ or performance IQ, as measured by age-appropriate Wechsler scales, and design fluency, as measured by D-KEFS. These same researchers employed exploratory regression analysis and determined that IQ was not a significant predictor of traditional or set shifting design and verbal fluency performance. Korkman et al. (2003), using correlation analysis, did however find significant relations between the Tower and Knock and Tap subtests (EF subtests from the NEPSY battery) and Verbal IQ, as assessed by WISC-III, and between the Tower subtest (but not the Knock and Tap subtest) and Performance IQ.

Whereas some studies of persons with FASD find IQ and certain aspects of EF to be related, others do not. In the case of individuals with FASD, the lack of a relation between EF and IQ may account for the limitations of IQ scores in predicting real-life behaviours. If EF underlies adaptive and maladaptive behaviours, then a failure to assess this aspect of cognitive processing might explain why scores from certain tests of intelligence fail to accurately reflect the functioning of assessed persons. The limitations of traditional IQ tests with this population highlight the inherent discord between a conceptualization of intelligence that continues to adhere to a general factor model, and specific cognitive deficits that result from the modular impacts of alcohol on particular regions of the brain. Clinical observations, such as those observed in individuals with FASD, have led many individuals to abandon the traditional conception of intelligence, focusing instead on contemporary models and theories of intelligence that emphasize the multidimensional nature of intelligence.

Multidimensional Theories of Intelligence

Evidence of Multidimensionality of Intelligence

Several lines of evidence challenge the notion that intelligence is a one-dimensional construct. To begin with, findings in neuropsychology are most consistent with differentiated cognitive functioning as opposed to undifferentiated or general brain function (Naglieri & Das, 2002). Research involving the functional organization of the brain and whether damage to certain parts leads to distinct or holistic insult dates back to the work of Karl Lashley (1950, 1963). Based on his research, Lashley concluded that the physical location of brain damage was less essential than the amount of brain tissue a lesion destroyed. His theory of mass action proposed that specific regions of the brain were not responsible for specific mental functions, rather that the brain functions as a whole. This theory was highly contentious and counter to findings of researchers such as Pavlov and Luria (Shallice, 1988). Luria's research provided evidence that anatomically distinct subsystems carry out separate functions. Pavlov and Luria, like many neuropsychologists today, recognized that although an intact brain may appear to function as a single, seamless attribute, the expression of its processing is the consequence of many discrete cognitive functions (Lezak, 1995). Insult impacting one module more than another may differentially affect domains of functioning (Frackowiak, Friston, Dolan, & Mazziotta, 1997). As different cognitive processes are aligned with different regions of the brain, the cognitive deficits associated with insult to one region of the brain may be very different than the deficits that result from insult to another region of the brain.

Research on savants provides additional evidence to challenge the unidimensional conception of intelligence and to support the idea that brain function is, at least to some extent, fractionated (Gardner, 1983). In the special case of savants, it becomes apparent that highly intelligent behaviour can be observed in individuals with severe cognitive limitations. Extraordinary talents in the areas of art, fine sensory discrimination, musical talent, memory, mathematics, and calendar calculation have been documented in individuals (savants) with mental retardation (Detterman, Gabriel, & Ruthsatz, 2000). The exceptional skills displayed by savants are incongruent with the theory of general intelligence (Detterman et al., 2000). The premise underlying the theory of general intelligence is that success in different domains of functioning can be accounted for by a latent general ability. This theory fails to explain how an individual with profound delays in many areas of functioning might perform beyond the level expected of non-disabled individuals in a few specific categories. Furthermore, if the brain were to have a general function, it would be extremely difficult to explain the exceptional abilities of savants in these very discrete areas of functioning.

Finally, frontal lobe syndrome could be used to argue against a unidimensional conception of intelligence (Das, 2002). To begin with, it has long been acknowledged in the field of neuropsychology that individuals with frontal lobe damage often continue to perform well on IQ tests despite their inability to function successfully within their environments (Crinella & Yu, 2000; Duncan et al., 1995). This evidence challenges the notion of general intelligence. It is difficult to understand how an individual can continue to do well on a measure that purportedly assesses an underlying general ability when this general ability fails to predict success in one's everyday life. Furthermore, findings related to individuals with frontal lobe syndrome challenge the notion of a general function of the brain. If one were to accept the idea of undifferentiated cognitive functioning then insult to the frontal lobes should result in an overall lowering of ability across domains. However, individuals who experience frontal lobe insult often evidence deficits in specific areas of functioning, namely those related to executive control. "To the extent that a particular faculty can be destroyed, or spared in isolation, as a result of brain damage, its relative autonomy from other human faculties seems likely" (Gardner, 1983, p. 63).

Contemporary Theories of Intelligence

Contemporary, multidimensional theories of intelligence reject the notion that intelligence can be distilled into one factor or entity that explains functioning in a range of domains of ability. Rather they contend that domains of functioning are independent of one another, or in some instances, interdependent on each other. Unlike so called "g theorists," multidimensional theorists argue (albeit on different grounds) in favour of different dimensions of intelligence, the total of which are inadequately captured by traditional IQ measures. Although some multidimensional theorists flatly reject the existence of a general factor of intelligence (Berg & Klaczynski, 2002), others like Gardner (1983) and Sternberg (1985) argue that the general factor narrowly applies to tasks used in tests of academic abilities. Sternberg (1985) explains the findings of a general factor of intelligence and the positive correlations observed among different measures of ability as a function of the fact that alternative theories on which measures and scores are based are "in many cases mathematically nearly equivalent" (p. 8). He contends that the reason we find a general factor of intelligence involves the similarity of tasks that are entered into the factor analysis (p. 67). Multidimensional theories of intelligence attempt to explain what processes might underlie success on academic tasks or they try to move beyond the realm of academic tasks traditionally equated with intelligence in order to account for various other domains in which intelligent behaviour can be observed.

PASS Theory of Intelligence

The Planning, Attention, Simultaneous and Successive (PASS) theory of intelligence provides a multidimensional view of intelligence influenced by neuropsychology, cognitive psychology and information processing. The roots of the PASS theory of intelligence are based on the work of Luria (Das, 1992), who applied information gained through clinical and experimental research of individuals with and without brain injury to explain a wide range of normal and atypical behaviours (Jarman & Das, 1996). The PASS theory of intelligence incorporates the three functional units of the brain identified by Luria. These functional units are associated with particular regions of the brain and provide "a base for identifying the four important processes involved in human cognitive competence" (Das, Naglieri, & Kirby, 1994, p.22). The PASS model of intelligence represents the dynamic relations between the processes of attention, simultaneous and successive processing, and planning, and the relations between these processes with knowledge base (Das et al., 1994). "The basic statement of the theory is that cognition can be understood as the result of the interdependent function of three neurological systems, those responsible for arousal (and attention), processing (or coding), and planning" (Kirby & Das, 1990, p.321). Although a particular task may predominantly involve one process over another, virtually all tasks performed in everyday life involve all four cognitive processes (Das et al., 1994).

Planning is one of the four cognitive processes included in this cognitive model. Although earlier research in this area focused primarily on the coding system and the particular importance of simultaneous and successive processing (Kirby & Das, 1990), the evolution of thinking behind this theory has led to an increased focus on planning processes (Das, Kar, & Parrila, 1996; Jarman & Das, 1996). Planning processes are involved in the generation, selection and execution of plans, and are necessary in order for an individual to efficiently and systematically solve a problem (Das et al., 1994). Although planning processes are distinct from attentional and coding processes, they play an important role in determining how attentional and coding processes should be used in order to successfully solve a problem (Das et al., 1994).

The planning processes identified within the PASS theory of intelligence may be relevant to deficits observed in individuals with FASD. Planning processes can be aligned with processes involved in executive functioning, an area of deficit observed in individuals with FASD (Bookstein et al., 2002; Connor et al., 2000; Kodituwakku et al., 1995; Mattson et al., 1999; Schonfeld et al., 2001). The cognitive processes described within the Planning Component of the PASS model involve actions that are consistent with the Supervisory Attentional System and that are relevant to executive functioning. Insofar as individuals with FASD evidence deficits in areas of executive functioning, they may also exhibit deficits in cognitive processes related to planning as conceptualized within the PASS model.

The CAS is based on the PASS theory of intelligence and was developed as a way to operationalize the model of cognitive components identified within the PASS theory (Naglieri & Das, 1997). Unlike scores derived from traditional tests of intelligence that are sometimes loosely based on theory, scores derived from the CAS offer a way to examine the unique profile of an individual with regards to his or her strengths and weaknesses in each of the four areas of cognitive processing (Das, 2002). Given that the components identified within this assessment system are based on theory and prior research findings, profile analysis of performance on tasks involved in the CAS may allow for meaningful interpretation of test scores that can ultimately direct remediation and address particular areas of need (Das, 2002; Naglieri, 2000).

Statement of the Problem and Hypotheses

CNS dysfunction is a significant consequence of prenatal alcohol exposure. Although traditional IQ tests offer one way to assess CNS dysfunction, there appear to be limitations to the application of these tests with alcohol-exposed persons. The predictive validity of IQ scores is tenuous as many persons with FASD achieve relatively high IQ scores despite significant adaptive and maladaptive problems. The limitations of traditional IQ tests at capturing EF might explain why the adaptive and maladaptive behaviours are worse than would be expected based on IQ alone. If deficits in EF underlie the adaptive and maladaptive behaviours of persons with FASD, it seems critical that tests of ability employed with this population measure this important area of cognitive functioning.

The rationale for the proposed study rests on findings that highlight the limitations of traditional IQ tests in capturing EF, and in predicting adaptive and maladaptive outcomes for persons with FASD. It is hypothesized that a test of intelligence based on strong theoretical grounding that incorporates the assessment of EF, along with other relevant areas of cognitive functioning, will provide a more accurate indication of an alcohol affected person's cognitive ability. The current study explored the relative utility of two tests of intelligence (WISC-IV and CAS) in predicting adaptive behaviour and in measuring EF in persons with FASD.

Hypothesis 1

Profile analysis will reveal distinct patterns of functioning on all measures employed (i.e., WISC-IV, CAS, ABAS-II, EF measures).

Hypothesis 1: WISC-IV

Relative to other indices derived from the WISC-IV, profile analysis will reveal particular deficits on the Working Memory Index.

Various studies in the area of FASD have employed earlier versions of the Wechsler Intelligence Scales for Children with children and adolescents with FASD (Mattson & Riley, 1998). Findings across these studies that have explored the profile analysis of WISC scores do not converge to indicate a reliable strength and weakness pattern. The WISC-IV is considerably different than its predecessor, the WISC-III, in that three new subtests have been added to the core battery (i.e., matrix reasoning, letter-number sequencing, and picture concepts), while other subtests have been modified and removed from the core battery (i.e., arithmetic and picture completion) (Baron, 2005). Furthermore, the elimination of both the Verbal IQ and Performance IQ factors (often the primary means for analyzing WISC-III results) makes it even more difficult to compare WISC-IV findings with those of previous literature based on earlier versions of this test. The current version of the WISC provides four domain index scores, along with a composite Full Scale IQ. The Working Memory Index represents that area most closely tied with our current understanding of EF. Based on the literature reviewed earlier in this document that suggests particular weaknesses in the area of EF for persons with FASD, it is hypothesized that participants within the current study will perform poorest on the Working Memory Index, relative to Verbal Comprehension, Perceptual Reasoning and Processing Speed.

Hypothesis 1: CAS

Profile analysis of scores derived from the CAS will reveal the Planning Component (aligned with EF) as a particular area of cognitive limitation.

This hypothesis was based on research findings previously discussed in the literature review that converge to suggest that EF deficits are common in persons with FASD (Rasmussen, 2005). This hypothesis was also based on achievement test results in children and adolescents with FASD as links between cognitive functioning, as assessed by the CAS, and areas of achievement can be made. Achievement test results indicating greater deficits in arithmetic and math for persons with FASD, relative to other areas of academic performance (e.g., reading and spelling), were relevant for this hypothesis (Coles et al., 1991; Kerns et al., 1997). While reading and spelling are thought to be more dependent on Simultaneous and Successive processing as described within the PASS theory (Das, Naglieri, & Kirby, 1994), arithmetic and math may be more dependent upon EF abilities (Bull & Scerif, 2001; Kopera-Frye, Dehaene, & Streissguth, 1996). If, as suggested earlier, individuals with FASD tend to perform better on measures of reading and spelling than on measures of math, it could be conjectured that they would perform better on Simultaneous and Successive processing than on Planning.

Attentional problems are often cited as characteristic of individuals with FASD (Jacobson & Jacobson, 2002), suggesting that participants may evidence low scores on the Attention component on the CAS. However, findings from studies that explore the attentional abilities of person with FASD are equivocal (Nanson & Hiscock, 1990; Coles et al., 1997). Not all studies of children with FASD have found behaviours consistent with ADHD when using measures of attention or neurocognitive tests (Coles, 2001).

Furthermore, the attentional profiles of individuals with FASD and those with ADHD may differ, despite superficial similarities (Coles et al., 1997). As exploratory factor analysis on the CAS originally found the Attention and Planning Componentss within the CAS to load together (Naglieri & Das, 1997), it is possible that deficits in EF may be seen across these two areas, and that participants with FASD will perform poorly in both Attention and Planning. Given that individuals with FASD consistently perform poorly on measures of EF (Kodituwakku, Kalberg et al., 2001), and not always on measures of attention (Coles, 2001; Jacobson & Jacobson, 2002), it is expected that scores will be somewhat lower on the Planning Component than on the Attention Component of the CAS.

Hypothesis 1: ABAS-II Parent and Teacher Forms

Profile analysis of scores derived from the ABAS-II Parent and Teacher forms will reveal the Social Domain as a particular area of adaptive weakness.

To our knowledge, there are no reported FASD studies that have employed the ABAS-II parent and teacher forms. It appears that most studies exploring the adaptive behaviours of persons with FASD and with prental alcohol exposure have made use of the VABS (Coles et al., 1991; Streissguth et al., 1996; Thomas et al., 1998; Whaley et al., 2001). Although the specific content and factor structure differ between the ABAS-II and the VABS, there appears to be some overlap between the domains of the VABS and that of the ABAS-II. As reported in the ABAS-II manual (Harrison & Oakland, 2003), the correlations between the ABAS-II Parent domain and global scores with the VABS Parent/Primary Caregiver Form domain and composite scores appear to be relatively high, with a range of coefficients between .49 and .74. Whereas the factors assessed by means of the VABS include Communication, Daily Living Skills, and Socialization, the ABAS-II is said to measure Conceptual, Practical and Social domains. Previous research using the VABS with a FASD population has found deficits across all areas assessed, however, there appear to be particular deficits in the area of Socialization, relative to Communication and Daily Living Skills (Carmichael Olson et al., 1998; Streissguth et al., 1991; Whaley et al., 2001). Given the correlation between the VABS Domain scores with the ABAS-II Domain scores, and in light of the overlap in content areas covered by both tools, it is hypothesized that, similar to findings on the VABS, participants will reveal deficits across all ABAS-II domains, but with a particular weakness in the area of social skills.

Hypothesis 1: EF as Measured by the WMTB-C and D-KEFS

Deficits will be observed across all EF tasks employed; however, deficits on certain EF tasks may be more pronounced than on others.

Deficits have been observed across a wide variety of EF tasks in persons with FASD (Rasmussen, 2005). As discussed earlier, few studies in the area of FASD have employed a comprehensive battery of EF tasks that have concurrently and directly assessed the three areas of functioning identified by Miyake et al. (2000) (i.e., Shifting, Working Memory, and Inhibition) and employed in the current study. This made it somewhat difficult to conjecture as to how participants might perform in one area of EF, relative to another area of EF. Comparisons of this study with other studies was further constrained in that deficits in many previous studies have been determined on the basis of comparison to control groups, not on the basis of mean scores relative to the normative mean. Several studies in the area of FASD have employed measures aligned with the EF processes of inhibition (Bookstein et al., 2002; Burden et al., 2005; Connor et al., 2000; Kodituwakku et al. 1995; Mattson et al., 1999; Noland et al., 2003; Rasmussen & Bisanz, 2005, October; Schonfeld, Mattson & Riley, 2005), updating/working memory (Burden et al., 2005; Carmichael Olson et al., 1998; Connor et al., 2000; Jacobson et al., 1998; Kerns et al., 1997; Rasmussen, 2006; Streissguth et al., 1994), and set shifting (Bookstein et al., 2002; Carmichael Olson et al., 1998; Connor et al., 2000; Coles et al., 1997; Kerns et al., 1997; Kodituwakku et al., 1995; Mattson et al., 1999; Rasmussen & Bisanz, 2005, October; Schonfeld et al., 2001). In several of these studies, EF deficits have been observed across all or nearly all tasks employed (Connor et al., 2000; Mattson et al., 1999; Schonfeld et al., 2001). Given this, it was hypothesized that participants within the current study would reveal deficits across EF tasks. Based on the findings of Miyake et al. (2000), Lehto et al. (2003) and Friedman et al. (2006) who found the construct of EF to be divided into separable EF functions, and in that individual EF tasks presumably measure different aspects of a construct, it was also expected that persons within the current study would evidence more pronounced deficits on certain tasks and in certain areas (i.e., Set Shifting, Working Memory, Inhibition) than on others.

Hypothesis 2

The CAS Full Scale Composite score and the CAS component scores will be significantly correlated with more EF scores (as derived from the D-KEFS and WMTB-C) than will the WISC-IV Full Scale score or WISC-IV Index scores.

Several CAS subtests appear to align with *inhibition* (Number Detection, Expressive Attention, Planned Codes), *set shifting* (Number Detection, Planned Codes) and more loosely with *working memory* (e.g., Sentence Repetition, Word Series) —

components identified by Miyake et al. (2000) and measured by the chosen EF tools. In comparison, WISC-IV subtests appear to align with *working memory* (Letter-Number Sequencing and Digit Span), but not with *inhibition* or *set shifting.*

Hypothesis 3

Compared with the WISC-IV and individual EF scores, the CAS and specifically the Planning and Attention Components of the CAS will be better predictors of adaptive behaviour as assessed by the ABAS-II.

Adaptive behaviour, as conceptualized within the Adaptive Behaviour Assessment System, appears to be dependent on both academic abilities (i.e., reading and writing abilities) and planning and problem solving abilities (e.g., Self-Direction Skill Area; Work Skill Area). It could be argued that Wechsler scales are good measures of academic abilities (Duncan et al., 1995), while EF scales are better at measuring novel problem solving abilities (Keil & Kaszniak, 2002). The CAS, in measuring cognitive processes necessary for both academic achievement and efficient planning and problem-solving, should offer the best means for predicting adaptive behaviour.

CHAPTER III: METHODS AND PROCEDURE

Participants

Thirty-eight children and adolescents, including 19 males and 19 females, between the ages of 8 to 16 years participated in this study. An additional seven participants were assessed, but not included in the analysis. Three of these seven participants were excluded because FASD diagnostic information could not be confirmed following testing. One of the seven was excluded due to non-compliance and behavioural difficulties throughout the testing session. Data for the remaining three participants was not included because of cognitive limitations that interfered with the completion of tasks (i.e., inability to read; inability to comprehend test instructions). For one of the 38 participants included, WISC-IV data were not available; information was provided that a recent assessment included the WISC-IV, however, follow-up revealed that it had not been administered as part of that battery. The mean age of participant children was 12.05 years (*SD = 2.96)*. All participants had a confirmed FASD-related diagnosis provided by physicians or by neuropsychologists who specialized in FASD assessment. Diagnoses falling under the FASD umbrella included FASD, FAS, FAE, ARND, Neurobehavioural Disorder–Alcohol Exposed, Neurobehavioural Disorder–Alcohol Exposed with Sentinel Physical Findings, and Static Encephalopathy–Alcohol Exposed (see Table 1). (Although FASD is not a diagnosis per se, for those participants described as having a diagnosis of FASD, more specific diagnostic information was not included in the assessment results provided to the parents/guardians and was not available to the researcher of this study). Children were excluded from the study if their age fell outside of the specified range, if English language proficiency could not be established, and/or if physical or academic limitations (e.g., reading ability) interfered with their ability to complete the various tasks included within the battery of administered tests. Sixty-eight percent of participants were reported to have an Aboriginal (i.e., Metis or First Nations) heritage, with Caucasian being the only other reported background. The majority of children lived in adoptive, foster and group home placements, where some of these placements involved kinship relationships. Of the 38 participants, 6 lived with a biological parent, 6 lived with a biological, non-parent relative (i.e., grandparent, aunt, or sister), and the remaining 26 participants lived in families that were not biologically related. See Table 1 for participant demographics. English was the predominant language spoken in the homes of 97 percent of the participants. Nineteen of the 38 participants were reported to be on medications at the time of assessment. Twenty-one of the 38 participants were said to have been involved in early intervention, and 27 of the 38 participants were reportedly in a special education classroom at some point in their educational history.

Procedure

The Health Research Ethics Board of the University of Alberta approved all procedures prior to participant recruitment. Participants were recruited through various regional FASD diagnostic clinics, local school boards, and community organizations. Recruitment posters were displayed at local community agencies and FASD conferences, and were distributed via a FASD list-serve to service providers throughout the province (see Appendix A). Parents and guardians of interested participants contacted the researcher. Based on an initial conversation outlining study details, eligibility for study

Table 1

Participant Demographics

Variable	Descriptives
Gender n	
Females	19
Males	19
Age (yr)	
Mean (SD)	12.05 (2.96)
Ethnicity n (%)	
Caucasian	12 (32)
Aboriginal	26 (68)
Home Environment n (%)	
Biological Parent	6 (15.79)
Biological Relative	6 (15.79)
Adoptive	8 (21.05)
Foster	9 (23.69)
Group Home	9 (23.69)
Language	
Only English	30
Mostly English	6
Cree	1
FASD Diagnostic Category	
FAS	13
ARND	9
FAE	2
FASD	3
SE:AE	7
ND: AE	3
ND:AE with SPF	1

Note. SE:AE = Static Encephalopathy - Alcohol Exposed; ND:AE = Neurobehavioral Disorder – Alcohol Exposed; ND:AE with SPF = Neurobehavioral Disorder, Alcohol Exposed with Sentinel Physical Findings. For one participant, full demographic information was not provided.

involvement was determined. If eligibility criteria were met, and interest remained, an assessment date and location were coordinated. Assessments were conducted at the university education clinic, within the child's school, or at local community agencies throughout the province. Informed consent was obtained from parents or guardians of participants acknowledging their consent for their child(ren) to participate in the study (see Appendix B). At the time of testing, assent was also obtained from participants themselves (see Appendix C). Release of information was sought from parents (guardians) to allow the researcher access to existing assessment data on participants when an overlap between study assessment tools and recent (i.e., within one year) assessment batteries was established (see Appendix B). Release of information was also sought to gain consent for communication between the researcher and teachers (or support workers) for completion of the ABAS-II Teacher Form (see Appendix B). At the time of assessment, parents or guardians were asked to complete a brief background information questionnaire that included items pertaining to the child's history and current school and family variables (see Appendix D), as well as the ABAS-II Parent Form. When parent (guardian) consent was offered, teachers were contacted via telephone to describe the study procedures and to elicit study participation (see Appendix E). The ABAS-II Teacher Form was described to interested teachers and questions regarding its completion were addressed.

Subsequent to completion of consenting procedures, children were administered the battery of assessment tools by the researcher or a graduate student trained in psycho-educational assessment and familiar with the tools. Testing lasted one session of approximately 4 to 5 hours. For one participant, the assessment was conducted over two sessions, each session lasting approximately 3 to 4 hours. During testing, participants were offered breaks as needed.

Measures

Five standardized assessment tools were used to explore the hypothesized relations. Participants with FASD were administered three comprehensive measures, including the WISC- IV, the CAS (Basic Battery), and subtests from the Delis Kaplan Executive Function System (D-KEFS), along with two working memory subtests from the Working Memory Test Battery for Children (WMTB-C). Parents (or guardians) of participants completed the parent form of the ABAS–II, along with a background information questionnaire. Participating teachers completed the teacher form of the ABAS-II.

Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)

The Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler et al., 2004) is based on the original Wechsler-Bellevue test of intelligence and represents the most recent version of the Wechsler tests for administration to children, ages 6 to 16 years. Unlike its closest predecessor, the WISC-III, which adhered to a Verbal/Performance index score structure, the WISC-IV provides four index scores including the Verbal Comprehension Index (VCI), the Perceptual Reasoning Index (PRI), the Working Memory Index (WMI), and the Processing Speed Index (PSI). Ten core subtests and five supplemental subtests, each contribute to an individual index score, and together comprise the WISC-IV.

Test development was divided into five general stages that included conceptual development, pilot, national tryout, standardization, and final assembly and evaluation. The WISC-IV was also standardized on a Canadian sample. Revision goals were reportedly based on extensive literature reviews, and expert guidance from professionals in a wide variety of fields. The test used for standardization was made up of a compilation of various groupings of subtests retained from the WISC-III, along with new, experimental subtests that had been explored within the national tryout stage. A stratified, nationally representative group of 2,200 American children, ages 6:0 to 16:11 years, including a representative number of children from other special groups (e.g. intellectually gifted, mild or moderate mental retardation, reading disorder), made up the standardization sample for the WISC-IV. Similarly, for the Canadian standardization of the WISC-IV, a stratified, representative sample of 1,100 children, ages 6:0 to 16:11 were recruited (Psychcorp, 2003). The ten core subtests that were retained and that contribute to each of the four index scores and the full-scale IQ score are described below.

Verbal Comprehension

Similarities. This subtest calls on examinees to recognize and articulate what is similar between a pair of presented objects or concepts.

Vocabulary. This subtest includes 4 picture items and 32 verbal items. Picture items were included to extend the floor of the subtest and require examinees to name what each picture represents. Verbal items require that examinees define words that an examiner reads aloud.

Comprehension. The Comprehension subtest incorporates items that require examinees to respond to questions that elicit an examinee's understanding of general principles and social situations.

Perceptual Reasoning

Block Design. Block Design is comprised of items where children are asked to recreate a presented model or picture using red and black blocks, within a specified period of time.

Picture Concepts. For each item within Picture Concepts, examinees are presented with 2 or 3 rows of pictures. Examinees are required to select items, one from each row, which are similar or belong to the same category.

Matrix Reasoning. Presented with an incomplete matrix, examinees are asked to choose from 5 response options, which missing portion would best complete the matrix.

Working Memory

Digit Span. Digit Span Forward and Digit Span Backward are the two conditions comprising the Digit Span subtest. Digit Span Forward asks examinees to repeat a sequence of numbers in the same order in which the examiner orally presented them. Conversely, Digit Span Backward requires examinees to repeat a sequence of numbers in the reverse order than that which the examiner presented them.

Letter-Number Sequencing. Orally presented with a sequence of combined numbers and letters, examinees are asked to recall the included numbers in ascending order and the letters in alphabetical order.

Processing Speed

Coding. Two forms of this subtest are provided, each form specified for a specific age group. Coding A is administered to examinees ages 6 – 7 years. Coding B is administered to examinees ages 8 – 16 years. Both coding forms are time-limited tasks that require an examinee to recognize which symbol is associated with its matched geometric shape or number, and to draw each symbol in its corresponding box or shape.

Symbol Search. Two forms of this subtest are provided, again each form specified for a specific age group. Symbol Search A is administered to examinees ages 6 – 7 years. Symbol Search B is administered to examinees ages 7 – 16 years. In each time-limited task examinees are asked to determine if a target symbol(s) is included within a row of symbols. Depending on their determination, he/she is to mark YES or NO at the end of each row.

WISC-IV - Canadian Standardization Sample Reliability

In the Canadian standardization sample, the reliability of WISC-IV subtests and composite scores was determined using the split-half method or alternatively, test-retest stability coefficients when processing speed and time limitations were incorporated in subtests. The average reliability coefficients of subtests within the WISC-IV ranged from a low of .79 to a high of .90. The average reliability coefficients of composite scales across the ages 6 – 16 years ranged from .90 (Perceptual Reasoning and Processing Speed) to .93 (Verbal Comprehension), with the average reliability of the Full Scale at .96. Further reliability investigations were also undertaken to determine how reliable this tool was when used with special groups (e.g. Mental Retardation – Moderate Severity; Learning Disorder and Attention-Deficit / Hyperactivity Disorder). Findings supported the reliability of this measure with special groups as reliability coefficients were similar to those reported for the normative sample.

WISC-IV – Validity

Wechsler scales are often criticized on the basis that they lack strong theoretical grounding. Part of the rationale for revising the WISC-III was to provide a tool more consistent with recent advances in intelligence theory and assessment, neuropsychology and cognitive development. Although an overarching theory of intelligence or information processing is not provided to support or defend the inclusion of certain scales of functioning within the WISC-IV, Wechsler does provide a brief theoretical rationale to justify the inclusion of new subtests said to capture fluid reasoning, working memory, and processing speed.

Beyond this attempt to establish the theoretical foundation of this tool, other evidence of the validity of the test is provided (Psychcorp, 2003; Wechsler et al., 2004). Extensive literature reviews, expert consultation and empirical examinations addressing response processes (e.g., patterns of incorrect responses on multiple choice items) for new subtests are reported to provide additional evidence of validity. Inter-correlations among subtests and composite scores were also offered as evidence of convergent and discriminant validity, where, for example, higher correlations among subtests contributing to the same scale were observed. Furthermore, consistent with hypotheses based on previous findings, certain subtests (e.g., Block Design, Similarities) found to correlate higher with the Full Scale IQ (*g*) than others, were also found to correlate higher with other high *g*-loading subtests from the same scale. Both exploratory and confirmatory factor analyses confirmed that across all ages the four-factor model provided the best fit for the data.

WISC-IV subtest and composite scores from the Canadian standardization sample were correlated with the Wechsler Individual Achievement Test – Second Edition (WIAT-II) subtest and composite scores (Psychcorp, 2003). The Full Scale Score derived from the WISC-IV correlated .80 with the WIAT-II Total Achievement score (a composite of Reading, Mathematics, Written Language and Oral Language), suggesting that the WISC-IV is a good predictor of achievement as assessed by the WIAT-II. WISC-IV index scores (i.e. VCI, PRI, WMI, and PSI) correlated between .20 (PSI and

Oral Language; PSI and Reading) and .76 (VCI and Reading) with WIAT-II composite scores.

The WISC-IV American Standardization sample scores were also correlated with three other related measures of intelligence including the WISC-III, the Wechsler Preschool and Primary Scale of intelligence – Third Edition (WPPSI-III), and the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III). Not surprisingly, these measures, some of which contain similar subtests correlated highly with each other. The same correlation of .89 was reported for the FSIQ-FSIQ between the WISC-IV and each of the other scales (WISC-III, WPPSI-III, and WAIS-III).

WISC-IV scores based on the American Standardization sample were also correlated with scores derived from the ABAS-II-Parent (ABAS-II-P; Harrison & Oakland, 2003) and Teacher (ABAS-II-T; Harrison & Oakland, 2003) forms. The WISC-IV FSIQ correlated .41 with the overall *General Adaptive* ABAS-II-P score, .49 with the *Conceptual* ABAS-II-P score, .35 with the *Social* ABAS-II-P score, and .28 with the *Practical* ABAS-II-P score. Higher correlations were found between the WISC-IV scores and the ABAS-II-T form. Here, the WISC-IV FSIQ correlated .58 with the *General Adaptive* ABAS-II-T score, .63 with the *Conceptual* ABAS-II-T score, .43 with the *Social* ABAS-II-T score, and .53 with the *Practical* ABAS-II-T score.

To establish the clinical utility of the WISC-IV and its validity with children and adolescents within various diagnostic categories (e.g., Intellectually Gifted, Mental Retardation, Reading and Written Expression Disorders, ADHD), several special group studies were conducted in the Canadian standardization of the WISC-IV. Despite the limitations with the sampling procedures and sample size, these studies were said to be consistent with expectations based on research and theory, and to support the validity of this tool for use with children in these special groups (Psychcorp, 2003).

Cognitive Assessment System

The Cognitive Assessment System (CAS; Naglieri & Das, 1997) is an individually administered, multidimensional test of intelligence based on the PASS theory of intelligence. Twelve subtests comprise the Standard Battery of this test, each subtest contributing to one of the scales of Planning, Attention, Simultaneous or Successive processing. Whereas the Standard Battery includes all subtests within the system, the Basic Battery is composed of eight subtests, two subtests contributing to each PASS scale. The CAS was standardized on a stratified, nationally representative sample of 2,200 American children, ages 5-17 years from regular and special education settings. The subtests included within this test were developed and included as a means to operationalize the four components of the PASS theory of intelligence. Each included subtest has been evaluated on the basis of pilot tests, research studies, a national tryout, and the national standardization of the CAS. The subtests within each cognitive processing scale are described below.

Planning

Matching Numbers. This task requires examinees to find and circle the two matching numbers in a row that includes a series of same length numbers. This task becomes increasingly difficult as numbers across different rows increase from one digit to seven digits. Various search strategies can be employed to enhance how systematically and efficiently an examinee completes this task.

Planned Codes. This task is divided into two conditions. In the first condition, examinees are asked to code letters of the alphabet (A,B,C, and D) on the basis of codes presented in a legend at the top of the page. Letters to be coded follow a specified order that is consistent across rows and columns. In the second condition, examinees are again asked to code letters on the basis of a new set of codes, also presented in a legend at the top of the page. In this condition, the letters to be coded follow a different pattern than those presented in the first condition. In this condition examinees are required to recall new codes, to recognize the existence of a different pattern relative to the first condition, and to employ an alternative strategy to successfully complete the task.

Attention

Expressive Attention. This test is based on the original Stroop test. Three conditions comprise this test, with conditions 1 and 2 establishing whether examinees have the non-executive component skills (ability to read the words red, blue, and green; ability to identify the colours of different rectangles) necessary for completion of condition 3. Condition 3 is the actual measure of expressive attention. Within this condition the words red, blue and green are printed in colours dissonant to the actual colour each word represents. Examinees are asked to name the colour used to print the word, making it necessary for him/her to inhibit the response to read the actual word.

Number Finding. Presented with rows of different numbers, examinees are asked to selectively identify certain numbers, only when they appear in a specific form. For example, examinees are required to circle the numbers 1, 2, and 3 when presented in boldface type, ignoring these same numbers when presented in regular-face type.

Simultaneous Processing

Nonverbal Matrices. Presented with an incomplete figural analogy, examinees are required to choose from among six possible designs that design which best completes an analogy.

Verbal Spatial Relations. In this task examinees are asked to identify which illustration of a possible six demonstrates the stated logical grammatical relations (e.g., “the ball in a basket on a table”).

Successive Processing

Word Series. This task calls on examinees to repeat single-syllable words presented in a series ranging from one to nine words in length.

Sentence Repetition. In this task children are orally presented with sentences of minimal meaning that use colour words in the place of nouns and verbs (e.g., The blue is graying). Sentence Repetition calls upon examinees to restate the sentence verbatim.

CAS - Reliability

Beyond the 2,200 children that made up the standardization sample, an additional 872 children participated in reliability and validity studies for the CAS. Reliability was determined using internal consistency reliabilities, and test-retest reliability coefficients. These analyses were conducted on individual subtests, each PASS scale, and for the composite CAS Full Scale for both the Standard and Basic Batteries. The highest reliability coefficients were found within the Standard Battery of the CAS, where the reliability of the Full Scale score across ages ranged between .95 to .97, followed by the average Simultaneous and Successive Scale scores (both .93), and the average Planning and Attention Scale scores (both .88). Scores derived from the Basic Battery of the CAS also suggest high internal reliability, where the reliability of the Full Scale scores across ages ranged from .85 to .90, and the average reliabilities were .90 for both the Simultaneous and Successive Scales, .85 for the Planning Scale, and .84 for the Attention Scale. Subtest reliabilities were also high ranging from a low of .75 to a high of .89 across subtests.

CAS – Validity

Theoretical grounding and empirical evidence support the validity of the CAS. As has been described, the CAS is strongly rooted in the PASS theory of intelligence where each CAS scale purportedly measures the cognitive processes identified in the PASS model.

The increase in scores across ages offers some indication that the CAS is sensitive to developmental gains in cognitive processing abilities. The higher positive correlations found between subtests contributing to each Scale indicate stronger relations within, as opposed to across, different Scales. This lends some support to the convergent and discriminant validity of the test. Confirmatory factor analysis further demonstrates the appropriateness of each subtest within its specified factor (PASS scale).

Empirical evidence also supports the constructs identified within the PASS model. Confirmatory factor analyses were conducted using the standardization sample (divided into 4 age ranges) and indicated a good fit between the four-factor PASS model and the data. Findings from the exploratory factor analysis differed somewhat from those of the confirmatory factor analyses. Here, one-factor and two-factor solutions were found to be insufficient across the 4 age ranges. A three-factor solution was sufficient for the 8-10 and 11-13 age groups, and a four-factor solution was sufficient for the 5-7 and the 14-

17 age groups. Further investigation based on the exploratory analyses indicated that the three-factor solution was the most stable. The distinction between the three and four factor solutions was dependent on whether Attention and Planning were separated. Despite the findings of the three-factor solution through exploratory analysis, Naglieri and Das (1997) decided to maintain the four-factor solution given other empirical, clinical, and theoretical evidence that supports the differentiation between the constructs of attention and planning.

The CAS Standard Battery and Basic Battery Full Scale scores, along with PASS Scale scores were correlated with the Woodcock-Johnson Revised (WJ-R) Tests of Achievement. Full Scale Scores derived from the Standard Battery and Basic Battery correlated .73 and .74 respectively with the WJ-R Skills cluster (a composite), suggesting that the CAS is a good predictor of achievement. PASS scales within the Standard Battery correlated between .50 and .67 with the WJ-R Skills cluster, and PASS scales within the Basic Battery correlated between .44 and .64 with this same cluster.

CAS Full Scale and PASS Scale scores were also correlated with scores derived from the WISC-III. Three samples of children (intellectually disabled, learning disabled, and regular education) were used to explore these relations. In general, Simultaneous and Successive scales correlated highest with the WISC Full Scale scores, with the exception of successive processing for the sample of persons with learning disabilities. Consistent with the test developers' hypotheses, the scales of Attention and Planning were least related with the WISC - III Full Scale scores.

Adaptive Behavior Assessment System – Second Edition

The Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003) is a norm-referenced tool that measures the functioning of individuals, ages birth to 89 years across 10 Adaptive Skill Areas. The ABAS-II was standardized on samples stratified by sex, race/ethnicity, and educational level parameters in accordance with the 1999 U.S. census data. Four standardization samples were formed based on the four major geographic regions outlined by the census reports, with a representative number of participants drawn from each region. Parent, teacher and adult rating scales are provided and can be used together or individually. Each scale was designed to gain information about clients within target environments (e.g., classroom) and from the perspectives of relevant informants. Norm-referenced scores from the 10 Adaptive Skill Areas contribute to an individual domain (Conceptual Domain, Social Domain or Practical Domain) and to an overall General Adaptive Composite (GAC). Based on scores derived from each of the 10 Adaptive Skill Areas, classifications of *Extremely Low, Borderline, Below Average, Average, Above Average*, and *Superior* can be used to describe functioning within each skill area and across all skill areas (i.e. GAC scores). The 10 Adaptive Skill Areas incorporated within this assessment tool are consistent with those outlined by the AAMR in the 2002 definition of mental retardation (American Association on Mental Retardation, 2002). They are also said to correspond to specifications outlined in the Diagnostic and Statistical Manual of Mental Disorder – Fourth Edition-Text Revision (DSM-IV-TR; American Psychiatric Association, 2000). These skill areas include Communication, Community Use, Functional Academics, Home/School Living, Health and Safety, Leisure, Self-Care, Self-Direction, Social, and

Work. With the exception of the Work skill area, all of the Adaptive Skill Areas are assessed for individuals across ages 5 to 89. A brief review of each of the skill areas is provided below.

Conceptual Domain

The *Communication Skill Area.* This skill area assesses speech, language and listening skills necessary for communication with others. Items within this area are said to measure an individual's vocabulary, conversation skills, and ability to respond to questions.

The *Functional Academics Skill Area.* This area aims to assess whether an individual has the basic reading, writing, mathematics and other academic skills necessary to accomplish daily tasks that are routinely involved in independent living (e.g. writing notes and letters, finding someone's telephone number in the phone book).

The *Self-Direction Skill Area.* Within the Self-Direction Skill Area, skills necessary for independence, responsibility and self-control are assessed.

Social Domain

The *Leisure Skill Area.* This domain aims to assess a person's skills as they relate to planning and engaging in recreational activities.

Social Skill Area. This area addresses an individual's ability to interact socially with others. Items also address how well an individual relates to others, whether an individual is able to maintain friendships with others, and how well an individual expresses and recognizes emotions in those around him/her.

Practical Domain

The *Community Use Skill Area.* The Community Use Skill Area addresses skills necessary to successfully function within the community. Items pertaining to use of community resources, mobility within the community and skills for shopping are included within this area.

The *Home/School Living Skill Area.* Within this domain items related to the physical maintenance of a home/work environment (e.g. cleaning, performing chores), and skills necessary for food preparation are incorporated.

The *Health and Safety Skill Area.* This area includes items that address an individual's ability to behave in accordance with safety rules, to respond to health and safety issues as they arise, and to exercise caution in those instances when deemed necessary.

The *Self-Care Skill Area.* Items incorporated in this area address an individual's personal care and his/her behaviours as they relate to eating, dressing, hygiene, use of toilet, bathing, etc.

Work Skill Area. This area is completed only for persons who have part or full-time employment, and addresses skills necessary for successful functioning in work environments. Items address issues such as how well an individual follows a work schedule, completes work-related tasks, and relates to supervisors.

ABAS-II – Reliability

Information gathered using the ABAS-II with the four standardization samples, supports that the ABAS-II has a high degree of reliability and validity. Measures of internal consistency (coefficient alpha), test-retest reliability (Pearson's product-moment correlation coefficient and Fisher's *z* transformation), inter-rater reliability (Pearson's product-moment correlation coefficient and Fisher's z transformation), and cross-form consistency (Pearson's product-moment correlation and Fisher's z transformation) were conducted on the standardization and clinical samples (e.g., ADHD, Learning Disability, Intellectual Deficiency) and generally suggest good to excellent consistency within and between the rating scales included in the ABAS-II.

The use of the ABAS-II has not been reported in previous studies exploring the adaptive behaviour of individuals with FASD. In that this measure, in the standardization process, was not validated specifically with an FASD sample, and given the nature of this tool as it lends itself easily to evaluation of reliability (as opposed to several other measures employed in this study

that would require test-retest reliability), the internal consistency of skill areas, domains and the GAC of both the ABAS-II Parent and Teacher forms were evaluated using Cronbach's alpha coefficients. Consistent with the results reported in the ABAS-II manual on other groups with disabilities, there were generally high reliability coefficients found across both the skill areas and domain scores on these measures within the current study (see Table 2).

ABAS-II – Validity

While the theoretical underpinnings of the ABAS-II adaptive skill areas are somewhat unsubstantiated, extensive empirical measures were undertaken to establish the validity of this tool for different age groups and for different populations (Harris & Oakland, 2002). The rationale for incorporating the 10 Adaptive Skill Areas within the ABAS rests on the AAMR 2002 definition of mental retardation, where these same 10 areas were outlined and described by the AAMR as important to successful independent functioning. Notwithstanding the practical appeal of having a measurement tool that is consistent with the diagnostic requirements for mental retardation, the developers of the ABAS-II do not provide strong evidence to support the inclusion, or conversely the exclusion of certain adaptive skill areas within the system. Despite this limitation, it appears that measures were taken to ensure that the content within each adaptive skill area logically fell within each domain. To begin, scale items were generated after an extensive review of relevant literature in the areas of developmental skills across the lifespan, functional skills necessary in different environments (e.g. home and school), and more generally on individuals with disabilities and other mental and health related problems. This review, along with the descriptions of adaptive skills provided by the AAMR (1992), guided the development of potential items for the ABAS-II. Experts in various related fields of work then subjected the item pool to review and based on this review several items were removed.

Correlational data collected from the standardization samples supported the one-factor model where adaptive skill areas (excluding the work skill area) all contributed to a unitary adaptive skill. The factor analytic results also supported a three-factor model that included the areas of Conceptual, Social and Practical adaptive domains in line with the AAMR's (2002) categorization of adaptive skill areas. To help establish concurrent validity, the ABAS-II Parent Form scores were correlated with the Vineland Adaptive Behavior Scale – Interview Edition in a non-clinical sample (VABS; Sparrow, Balla, & Cicchetti, 1985). The Vineland includes domains of Communication, Daily Living Skills,

Table 2

ABAS-II Parent and Teacher Internal Consistency Coefficients

	Parent Form *n = 38*	Teacher Form *n = 27*
Skill Area		
Communication	.86	.91
Functional Academics	.95	.93
Self-Direction	.94	.90
Community Use	.94	.84
Home / School Living	.91	.93
Health and Safety	.91	.87
Self Care	.91	.88
Leisure	.93	.90
Social	.95	.91
Domain		
Conceptual	.96	.96
Social	.97	.95
Practical	.97	.95
Global Adaptive Composite	.99	.98

Note. Consistency coefficients represent Cronbach's Alpha coefficients.

and Socialization. Correlations amongst the 9 ABAS-II adaptive skill areas (excluding the Work Skill area) and the Vineland Adaptive Behavior Scale-Interview Edition (VABS-IE) domains ranged from a low of .30 (between the ABAS-II Self-Care areas and the VABS-IE Communication) to a high of .68 (between ABAS-II Leisure area and the VABS-IE Communication). The correlation between the overall composites derived from the ABAS-II Parent Form and the VABS-IE was .70. The ABAS-II Parent Form GAC (without Work Skill area) correlated .61 with the VABS Communication domain, .58 with the VABS Daily Living Skills domain, .58 with the VABS Socialization domain.

Delis Kaplan Executive Function System

The Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001a) is a relatively comprehensive assessment tool that assesses a range of EF abilities that might align with the Supervisory Attentional System (SAS) and with Miyake et al.'s (2000) model of EF. The D-KEFS is comprised of nine tests of verbal and nonverbal executive functions. Several of the included tests are thought to measure inhibition and set shifting, two of the EF components identified by Miyake et al. (2000) and implicated in the SAS. For the purposes of the current study, four tests from the D-KEFS were used; two tests to assess set shifting and two tests to measure inhibition. The Verbal Fluency–Category Switching test and the Design Fluency–Switching test were used to as measures of set shifting. The Color Word Interference Test: Inhibition Total Errors score and the Tower Test Achievement score were used as measures of inhibition. Although tower tests are often described as measures of planning, there is some research to suggest that inhibition, as opposed to planning, is most relevant to successful completion of tower related puzzles (Goel & Grafman, 1995; Miyake et al., 2000). For this reason, the D-KEFS Tower Test was used as a measure of inhibition. The D-KEFS does not include measures specifically aligned with working memory, and thus additional working memory measures were included in the battery (see below).

The D-KEFS tests were nationally normed on 1,700 American children and adults, ages 8 to 89 years. This system was designed to allow for the individual administration and interpretation of one or, conversely, all of the nine tests. There are several advantages of employing this system over other measures of EF. The most obvious advantage involves the comprehensiveness of the system, where a range of EF tasks are incorporated to allow for assessment of this complex, multifactorial domain of cognition (Delis et al., 2001a). Other attributes of the D-KEFS are the inclusion of tests that separately target verbal and nonverbal cognitive functions; the isolation of fundamental skills from higher-level EF skills; and the enhancement of test sensitivity to mild brain damage (by means of incorporating more cognitive-switching tasks, by adding capture stimuli to draw an examinee's attention away from higher level thinking, by increasing the threshold of processing demands over those of similar clinical tests; and by incorporating higher ceilings and lower floors across the tests). In line with the Miyake et al. (2000) model of EF, the D-KEFS includes several measures of inhibition (i.e., Color-Word Interference, Tower-Test, Design Fluency) and set shifting (i.e., Trail Making, Verbal Fluency, Sorting Test). The four D-KEFS tests that were administered within the context of the proposed study are described below.

D-KEFS Verbal Fluency Test. The Verbal Fluency Test is comprised of three tests including Letter Fluency, Category Fluency, and Category Switching. This test aims to measure an examinee's ability to fluently generate words that begin with a certain letter

(Letter Fluency),and that belong to a semantic category (Category Fluency), and that alternate between two designated semantic categories (Category Switching). The Verbal Fluency–Category Switching scaled score was the focus of analyses in the present study.

D-KEFS Design Fluency Test. This test measures an examinee's ability to connect dots for the purpose of drawing as many different designs as possible, using only four straight lines, while adhering to a given rule (e.g., alternately connect filled and empty dots). There are three conditions within this test, each progressively more complex than the last. Taken together, the tasks measure design fluency, response inhibition, and cognitive flexibility. For the current study, the focus of analyses was on the Design Fluency–Switching scaled score.

D-KEFS Color-Word Interference Test. Based on the Stroop (1935) procedure, this test was designed to measure an examinee's ability to inhibit a prepotent verbal response (i.e., reading the printed words) when shown names of colours, presented in dissonant ink tones. Four conditions comprise this test. The first two conditions establish whether an examinee has the component cognitive skills necessary for completion of the tasks. The third condition measures inhibition as in the traditional Stroop task. The fourth condition adds to the complexity of the traditional Stroop task by asking examinees to alternate between naming the dissonant ink colours and reading the printed words. This final condition is said to measure both inhibition and cognitive flexibility. For the purposes of this study, the Color Word Interference Test - Inhibition Total Errors scaled score was the focus of analyses as this score is most closely aligned with inhibition.

D-KEFS Tower Test. This test asks examinees to build a designated tower, moving disks of varying sizes across three pegs. The tower test becomes progressively more complex as both the number of disks and the minimum number of moves to achieve the designated tower increase. Examinees are encouraged to complete the tower in as few moves as possible while adhering to two test rules. This test is said to assess a range of executive functions including spatial planning, rule learning, inhibition, and the ability to establish and sustain the instructional set. For the purposes of this study, the Tower Test Total Achievement scaled score was the focus of analyses.

Delis-Kaplan – Reliability

Various reliability methodologies were employed to assess the consistency of scores derived from the D-KEFS tests (Delis et al., 2001b). At times, the nature and procedures of some D-KEFS tasks restricted the types of reliability methodologies that could be conducted. Item interdependence, where repeated trials involved the same stimuli, was offered as one reason why certain internal-consistency analyses may be inappropriate. Denckla (1994) addressed the difficulties of measuring test-retest reliability of executive functioning tasks. A defining feature of EF tasks is that they are novel and unfamiliar to the examinee. "Unless the individual is amnesic for procedures, it is inherently illogical to expect the same sort of test- retest properties traditional for content-focused measures" (p. 122). Depending on the suitability of the methodologies, internal consistency, test-retest reliability, and alternate-form reliability were measured across different D-KEFS tests. In general, the consistency of scores within the D-KEFS tests could be described as moderate to good.

Delis-Kaplan - Validity

Historically, validity was defined as the composite of criterion-related, content-related, and construct-related evidence of a measurement tool (Shepard, 1993). While these trinitarian distinctions still influence how we conceive validity, more emphasis is currently placed on the concept of unified construct validity and the consequences of test score interpretation (Messick, 1989). Specifically, Messick (1989) defines validity as an "integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment" (p. 13).

The validity of a measurement tool is significantly strengthened when strong theoretical arguments are made to defend the inclusion, and conversely the exclusion, of certain test items. Despite the relevance of theory when developing assessment tools, Delis et al. (2001a) defend the omission of a theoretical model to support the D-KEFS on grounds that tenuous understanding of frontal lobe functioning does not allow for such a theory at this time. Although a theoretical model was not used to guide the development of this overall system, other evidence of validity for each of the D-KEFS tests was offered. Many of the tests that comprise this system are modifications of other tests that have been historically used to assess brain dysfunction. Findings from various studies that employed some of the D-KEFS measures were used to establish how persons with presumed or known brain dysfunction perform lower than controls with normal brain functioning. Insofar as D-KEFS tests can discriminate between groups of brain-injured and non brain-injured persons, there is some evidence of the validity of the D-KEFS measures. Positive correlations between groups of D-KEFS tests (verbal vs. nonverbal), and between individual D-KEFS tests offer some indication that these tests might be measuring the same construct. Furthermore, these correlations across different tests lend some support to an overarching EF construct. The degree of these correlations were said to increase marginally with age.

Working Memory Test Battery for Children (WMTB-C)

The Counting Recall and Listening Recall tests from the Working Memory Test Battery for Children (WMTB-C; Pickering & Gathercole, 2001) were used to measure working memory in participants within the current study. The theoretical underpinnings and the choice of measures included in the WMTB-C were guided by Baddeley's (1996) model of working memory which differentiates between the phonological loop, the visuo-spatial sketchpad, and the central executive, the latter of which the Counting Recall and Listening Recall tests are said to measure (Pickering & Gathercole, 2001). Test construction began with a prototype version of the working memory battery with a group of children aged 6 to 7 years. Modifications to the testing battery were made on the basis of findings of this original protoype version. The WMTB-C includes a total of nine individually administered tests that were standardized on a sample of 750 children, ranging in age from 4 to 15 years, and recruited from seven local, rural and urban schools within the United Kingdom. Schools chosen for this standardization study were selected on the basis that their students were representative of the national population, and that they were performing at levels commensurate with local and national average in assessments.

WMTB-C – Reliability

Test-retest reliability on all WMTB-C tests was conducted on a sub-sample of 99 children selected from the original standardization sample. With a two week interval separating the initial and subsequent testing sessions, the reliability of Grades 1 and 2 students on the Listing Recall and Counting Recall tests were relatively high (.83 and .74 respectively), but were lower for students in Grades 5 and 6 on the same tests (.38 and .48 respectively).

WMTB-C – Validity

Both exploratory and confirmatory factor analyses of all nine WMTB-C tests were said to correspond closely with the tripartite structure of the working memory model. Based on factor analyses applied to different age groups, it was determined that although the same three-factor structure fitted the data at all age levels, some developmental changes across age bands were apparent. For example, as age increased, the connection between the central executive factor, inclusive of the Counting Recall, Listening Recall and Digit Span tests, and the phonological loop factor became stronger, while at the same time, the link between the phonological loop factor and the visuo-spatial sketchpad factor declined in the older age groups. Correlational findings between achievement scores derived from various standardized picture vocabulary, reading, spelling and arithmetic measures, and the composite central executive (as derived from the prototype version of the WMTB-C) were found to be significant for seven and eight-year-old children. Again on the basis of data from both the prototype version of the WMTB-C and on the WMTB-C final form, various studies have found performance on working memory tasks to be correlated and predictive of scores on National achievement tests in the areas of English and Mathematics. Offering further evidence of the validity of the WMTB-C, research suggests that relative to non-disabled peers, children identified as requiring special needs and those described as having dyslexia, performed poorer on the WMTB-C tests.

Counting Recall. In this task originally developed by Case, Kurland, and Goldberg (1982), examinees are presented with a series of cards covered by varying numbers of red dots. Before the test trial and the subsequent presentation of each set of cards, examinees are instructed to point with their finger and state aloud as they count each red dot on an individual card, and to then remember the number tallied for each card. After the final card in a set of cards is presented, examinees are asked to recall, in order, the number of red dots counted on each presented card. This task requires examinees to simultaneously process and store information and has a reported mean test-retest reliability of .61 (Gathercole, Pickering, Ambridge, & Wearing, 2004).

Listening Recall. Based on Daneman and Carpenter's (1980) listening span test, this task requires examinees to listen to a series of short statements of moderate difficulty, to determine the veracity of each statement by responding "true" or "false", and after presentation of each series of statements, to recall the last word of each statement in the same order in which it was presented. In that participants are required to process the information as well as remember the last word in each statement, this task is thought to measure complex memory (Gathercole et al., 2004). This test has a mean test-retest reliability coefficient of .61 (Gathercole et al., 2004).

CHAPTER IV: RESULTS

To begin this chapter, the descriptive statistics and distributional properties of all variables included are described. Outliers were determined on the basis of a two standard deviation decision rule. Distributional properties of the data and violations to normality were further evaluated using skewness and kurtosis statistics. A commonly used test of normality was employed, whereby the skewness and kurtosis statistics are divided by their standard errors (Garson, 2006). Those values falling within a -2 to +2 range were considered normally distributed. For those variables with scores falling outside of this range, square root transformations were conducted to achieve a normal distribution and to enhance correlational analyses (Tabachnick & Fidell, 1996). Transformed variables were only used with correlational data analysis, not when analyzing mean performance.

Following the description of descriptive statistics, results are then presented according to each relevant hypothesis. To address Hypothesis 1, means were compared using ANOVAs and *t*-tests, as appropriate, to determine patterns of relative strengths and weaknesses for FASD children. For the individual EF measures employed (i.e., Listening Recall, Counting Recall, Verbal Fluency, Design Fluency, Colour Word Interference, Tower Test), mean standard scores were compared to the normative means using one-sample *t*-tests with 99% confidence intervals. Given the differences in standardized scales used across the EF measures (i.e., WMTB-C and D-KEFS) and in light of the fact that EF scores were derived on the basis of different normative samples, an overall repeated measures ANOVA was not conducted. Hypothesis 2 addressed the correlations between EF measures and scores derived from the WISC-IV and CAS. Finally under Hypothesis

3, hierarchical linear regression analyses were used to predict parent- and teacher-rated adaptive behaviour. Data were analyzed using SPSS version 11.0. and the data analytic approach is outlined under each hypothesis explored. For all analyses the alpha level was set at the .05 level.

Descriptive Statistics

WISC-IV

No outliers were identified on any of the WISC-IV index distributions, nor were WISC-IV index skewness or kurtosis statistics outside of the -2 to +2 range when each statistic was divided by its standard error (Garson, 2006). A summary of the descriptive statistics for the 10 WISC-IV subtest scores, the 4 WISC-IV composite indices (i.e., Verbal Comprehension Index -VCI; Perceptual Reasoning Index – PRI; Working Memory Index – WMI; and Processing Speed Index – PSI), and the WISC-IV Full Scale IQ (FSIQ) is presented in Table 3. The mean FSIQ was 81.46, with a standard deviation of 10.66.

CAS

Applying a plus or minus 2 standard deviation decision rule, no outliers were identified on any of the CAS component scores. An evaluation of the skewness and kurtosis of CAS component scores revealed that for both the Planning Component and the Attention Component, violations were present. The Planning Component was slightly negatively skewed (Skewness: -.92; Std. Error: .38), and the Attention Component was both slightly negatively skewed (Skewness: -.96; Std. Error: .38) and peaked (Kurtosis: 2.58; Std. Error: .75). Given that both distributions were negatively skewed, each variable

Table 3

WISC-IV Subtest and Composite Mean Scores

	M	*Median*	*SD*	*Range*	*Skewness*	*Kurtosis*
Subtest						
Similarities	7.86	7.00	2.59	2 - 14	.37	.51
Vocabulary	7.00	7.00	2.55	1 - 13	.09	-.27
Comprehension	7.62	8.00	2.75	2 - 13	-.06	-.20
Block Design	8.22	8.00	2.36	4 - 14	.47	.04
Picture Concepts	8.49	9.00	2.64	2 - 14	-.13	.11
Matrix Reasoning	8.05	7.00	2.73	3 - 14	.57	-.31
Digit Span	7.27	7.00	2.17	1 - 12	-.20	.94
Letter-Number	5.95	6.00	2.91	1 - 12	.13	-.89
Coding	6.62	6.00	2.67	1 - 12	.23	-.29
Symbol Search	7.62	8.00	2.78	1 - 11	-.73	-.02
Index						
VCI	85.59	87.00	14.31	50 - 110	-.55	.36
PRI	88.68	87.00	12.17	68 - 114	.30	-.35
WMI	80.43	77.00	12.47	50 - 105	.01	.15
PSI	83.95	85.00	12.32	62 - 103	-.08	-.92
FSIQ	81.46	80.00	10.66	53 - 105	.05	.68

Note. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full Scale Intellectual Quotient.

n = 37

was reflected by subtracting the actual score from X, where X was equal to the largest score + 1. These reflected variables were then transformed using a square root transformation (Tabachnick & Fidell, 1996). Subsequent to this transformation, the Planning Component (Skewness:.03; Std Error: .38; Kurtosis: .08; Std. Error: .08) became normally distributed. Such was not the case for the Attention Component (Skewness: -.34; Std. Error: .38; Kurtosis: 1.60; Std. Error: .75), where the square root transformation reduced both the skewness and kurtosis but did not reduce the kurtosis to within the acceptable range. Following this, both the log transformation and the inverse transformation of the Attention Component distribution were employed; however, both transformations substantially increased the skewness and the kurtosis. Based on the success of the initial square root transformation of the Attention Component distribution at reducing the skewness, this transformed variable was used in all correlational analyses. The results for these reflected and transformed variables are corrected for direction to allow for simplified interpretation. Descriptive statistics for the eight CAS subtest scores, the four CAS component scores (Planning; Attention; Simultaneous Processing; and Successive Processing) and the CAS Full Scale (FS) composite score are presented in Table 4.

ABAS-II

Parent Form and Teacher Form

There were no outliers identified within the ABAS-II Parent or Teacher Domain distributions, nor were the skewness and kurtosis scores found to fall outside of the -2 to +2 acceptable range when each statistic was divided by its standard error (Garson, 2006). Descriptive statistics for the ABAS-II Parent Form skill areas, adaptive domains

(Conceptual, Social, and Practical) and Global Adaptive Composite (GAC) are presented in Table 5. Of the 38 teachers, 27 returned completed ABAS-II Teacher Forms. A summary of the descriptive statistics for the ABAS-II Teacher Form skill areas, adaptive domains and the GAC is also presented in Table 5.

Table 4

CAS Subtest and Composite Mean Scores

	M	*Median*	*SD*	*Range*	*Skewness*	*Kurtosis*
Subtest						
Matching Numbers	7.61	8.00	2.09	3 - 11	-.40	-.49
Planned Codes	7.55	8.00	2.05	3 - 12	.01	-.44
Nonverbal Spatial	8.58	9.00	2.29	2 - 12	-.75	.74
Verbal Spatial	9.55	9.00	2.42	5 - 15	.31	-.36
Expressive Attention	8.89	8.50	2.35	2 - 15	-.15	1.61
Number Detection	8.45	9.00	1.97	3 - 12	-.62	1.13
Word Series	7.79	8.00	2.77	1 - 15	-.20	.68
Sentence Repetition	7.71	8.00	2.21	3 - 13	.10	.57
Component						
Planning	85.63	85.00	8.99	59 - 100	-.92	1.09
Simultaneous	94.39	94.00	11.98	67 - 115	-.18	-.22
Attention	92.11	94.00	10.37	57 - 112	-.96	2.58
Successive	87.66	89.00	11.67	61 - 120	.30	.94
CAS Full Scale	85.89	88.00	10.50	55 - 105	-.70	.65

Note. $n = 38$

Table 5

Parent and Teacher ABAS-II Skill Area and Domain Scores

	Parent Form (n = 38)					*Teacher Form (n = 27)*				
	Mean (SD)	*Median*	*Range*	*Skew -ness*	*Kur- tosis*	*Mean (SD)*	*Median*	*Range*	*Skewness*	*Kurtosis*
Skill Area										
Communication	6.37 (2.80)	6.00	2 – 13	.33	-.03	5.07 (3.68)	3.00	1 – 12	.61	-1.20
Community Use	6.47 (3.19)	7.00	1 – 15	.36	.82	7.22 (3.37)	8.00	1 – 13	-.39	-1.02
Functional Academics	5.24 (2.99)	5.00	1 – 13	1.00	.86	6.70 (2.76)	7.00	2 – 12	.22	-.58
Home or School	3.95 (3.21)	3.00	1 – 13	1.29	.96	6.15 (4.02)	7.00	1 – 13	.16	-1.56
Health and Safety	5.89 (3.41)	5.50	1 – 12	.26	-1.18	7.04 (3.46)	8.00	2 – 12	-.18	-1.53
Leisure	5.79 (3.53)	6.00	1 – 14	.21	-.72	6.85 (3.17)	7.00	2 – 13	.15	-.74
Self-Care	5.89 (3.31)	6.00	1 – 12	.20	-1.12	7.44 (3.72)	9.00	1 – 12	-.47	-1.41
Self-Direction	3.32 (2.76)	2.50	1 – 11	1.27	.96	5.04 (3.38)	4.00	1 – 11	.58	-1.08
Social	4.68 (4.13)	3.00	1 – 15	.81	-.59	6.26 (3.38)	7.00	1 – 12	.06	-1.33
Domain										
Conceptual Domain	72.97 (13.69)	71.00	51 – 112	.64	.41	80.59 (16.02)	84.0	53 – 116	.22	-.66
Social Domain	76.45 (18.09)	73.50	54 – 120	.52	-.71	83.19 (16.21)	86.0	58 – 116	.32	-.52
Practical Domain	72.68 (19.54)	75.00	42 - 120	.29	-.31	85.41 (17.03)	86.0	47 – 120	-.37	.35
Global Adaptive Composite	70.29 (17.63)	68.50	44 - 120	.73	.48	80.74 (18.06)	84.0	45 – 116	.13	-.44

EF as Measured by the WMTB-C and D-KEFS

Six EF tasks — two from the WMTB-C and four from the D-KEFS — were used to tap the three target executive functions (i.e., Set Shifting, Working Memory, and Inhibition). Scores derived from the D-KEFS Verbal Fluency and Design Fluency tests were used as measures of Set Shifting. The WMBT-C Listening Recall and Counting Recall tests were used to operationalize Working Memory. Finally, the D-KEFS Colour Word Interference Test and Tower Test were used to measure the construct of Inhibition. Raw scores from each EF task were calculated and then converted to scaled scores and standard scores according to procedures outlined within the respective testing manuals. Raw scores from the D-KEFS were converted to scaled scores with a mean of 10 and standard deviation of 3. The D-KEFS offers primary and secondary outcome measures. For the purposes of all analyses of D-KEFS measures, aside from the Color Word Interference Test, the primary EF measures were used. For the Color Word Interference Test, error scores on the Inhibition condition were used, given that this score is more directly linked with inhibition (Delis et al., 2001a). Raw scores from the WMTB-C were converted to standard scores with a mean score of 100 and a standard deviation of 15. The normative sample of the WMTB-C ends at 15 years, 9 months, leaving out five 16-years-olds assessed on this measure in the current study. Research conducted on the WMTB-C Counting Recall and Listening Recall, two tests employed in the present study, suggests that abilities measured by these two particular tests level off at the age of 14 to 15 years. Based on this finding, it is arguable that the normative data from the 15-year-old sample would map on closely with the scores of a 16-year-old sample, thus applying the 15-year-old standardized scores to the 16-year-old raw scores within this study does not seem to be a large departure from the findings of the literature (Gathercole et al., 2004). It is however possible that scores on these two tasks might slightly overestimate abilities for those participants for whom normative data were not available and for whom 15-year-old standardized scores were applied.

Prior to analyses, all EF score distributions were evaluated for outliers and for non-normality on the basis of skewness and kurtosis values. No outliers were identified, nor were skewness or kurtosis statistics found to fall outside the acceptable range, when divided by their standard errors (Garson, 2006). Three of the six mean EF scores fell in what would be described clinically as the average range, while the remaining three fell in the low average range of functioning (see Table 6).

Table 6

EF Mean Scores

	M	*Median*	*SD*	*Range*	*Skewness*	*Kurtosis*
Listening Recall	90.39	88.5	18.86	56 – 143	.50	.62
Counting Recall	81.82	84.00	16.88	54 – 109	-.10	-.99
Verbal – Switch	7.89	8.00	3.07	1 – 15	-.03	.17
Design – Switch	9.03	9.00	3.11	3 – 18	.29	.54
Color Word[a]	7.39	7.00	3.32	1 – 13	-.23	-.64
Tower Test	9.32	9.00	3.25	3 - 16	.26	-.34

Note. $n = 38$. [a]$n = 36$ due to administration error.

Hypotheses

Hypothesis 1

Profile analysis will reveal distinct patterns of functioning on all measures employed (i.e., WISC-IV, CAS, ABAS-II, EF Measures).

Hypothesis 1: WISC-IV

Relative to other indices derived from the WISC-IV, profile analysis will reveal particular deficits on the Working Memory Index.

Prior to analysis of the WISC-IV index scores, age, gender and ethnicity (Aboriginal and non-Aboriginal) were evaluated as possible covariates using Pearson's correlation coefficients. None of the variables examined were found to correlate with the WISC-IV index scores and these variables were thus excluded from further analyses. A simple repeated measures ANOVA of WISC-IV cognitive indices was then conducted. Mauchly's Test of Sphericity was used to test the null hypothesis that the variances of differences for all pairs of levels of the repeated measures factor were equal, and a non-significant finding suggested that the assumption had been met. The repeated measures ANOVA indicated an effect of component, $F(3, 108) = 4.05, p < .05$. Follow-up comparisons were then conducted (see Table 7 for results; means in Table 3). These comparisons revealed that participants performed significantly better on the Verbal Comprehension Index and the Perceptual Reasoning Index than they did on the Working Memory Index. The Perceptual Reasoning Index was also higher than the Processing Speed Index. These findings were found to support the original hypothesis that more pronounced deficits would be observed in the area of Working Memory.

Table 7

WISC-IV Index Follow-up Comparisons

Paired Indices	t	p
VCI - PRI	-1.25	.220
VCI - WMI	2.11	.042
VCI - PSI	.65	.522
PRI - WMI	3.12	.004
PRI - PSI	2.31	.026
WMI - PSI	-1.55	.131

Note. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full Scale Intellectual Quotient.

$df = 36$

Hypothesis 1: CAS

Profile analysis of scores derived from the CAS will reveal the Planning Component (aligned with EF) as a particular area of cognitive limitation.

Before analyzing CAS component scores, age, gender and ethnicity (Aboriginal and non-Aboriginal) were assessed as possible covariates using Pearson's correlation coefficients. As none of these variables were significantly correlated with CAS component scores, they were removed from future analyses. A simple repeated measures ANOVA of CAS cognitive components was conducted. Mauchly's Test of Sphericity indicated that the sphericity assumption was violated and that the variances of differences for all pairs of levels of repeated-measures factors were not equal. Given this violation, the Greenhouse-Geisser correction was used, $F(2.27, 84.07) = 7.29, p < .05$.

Follow-up comparisons revealed that participants performed better on the Simultaneous Processing Component as compared to the Planning Component and the Successive Processing Component, but not in comparison to the Attention Component. The mean Attention score was higher than both the mean Planning score and the mean Successive Processing score. Finally, no difference was found between the mean Planning score and the mean Successive Processing score (see Table 8; means in Table 4). In line with the original hypothesis, these findings were suggestive of particular deficits in the area of Planning.

Table 8

CAS Component Follow-up Comparisons

Paired Components	*t*	*p*
Planning – Simultaneous	-3.92	.000
Planning – Attention	-5.71	.000
Planning – Successive	-1.04	.307
Simultaneous – Attention	.94	.353
Simultaneous – Successive	2.62	.013
Attention – Successive	2.26	.030

Note. *df* = 37 for each comparison.

Hypothesis 1: ABAS-II

Profile analysis of scores derived from the ABAS-II Parent Form and Teacher Form will reveal the Social Domain as a particular area of weakness, relative to the Conceptual and Practical Domains.

ABAS-II Parent Form. Before analyzing ABAS-II Parent domain scores, age, gender and ethnicity (Aboriginal and non-Aboriginal) were assessed as possible covariates using Pearson's correlation coefficients. As none of these variables were significantly correlated with ABAS-II Parent domain scores, they were removed from future analyses. A simple repeated-measures ANOVA was then performed to determine whether a difference between parent-rated adaptive domains existed. Mauchly's Test of Sphericity indicated that the assumption of sphericity was met. The repeated measures ANOVA across the three domain scores indicated an effect of domain, $F(2, 74) = 3.11$, $p = .05$. Follow-up comparisons revealed that the Social Domain Composite was significantly higher than both the Conceptual Domain Composite, $t(37) = -2.09$, $p < .05$, and the Practical Domain Composite, $t(37) = 2.39$, $p < .05$, with no difference found between the latter two, $t(37) = .16$, $p > .05$. This finding was counter to the original hypothesis that weaknesses would be observed in the Social Domain.

ABAS-II Teacher Form. Age, gender and ethnicity (Aboriginal and non-Aboriginal) were assessed as possible covariates of the ABAS-II Teacher domains. Neither gender nor ethnicity significantly correlated with the ABAS-II Teacher domains, however age was negatively associated with the ABAS-II Teacher Social Domain, $r(25) = -.42$, $p < .05$. Given this association, age was included as a covariate in the repeated measures ANOVA design. Mauchly's Test of Sphericity indicated that the assumption of sphericity was met. The repeated measures ANOVA across the three domain scores did not indicate a main effect for adaptive domain, $F(2, 50) = 1.36, p > .05$, a between subjects factor effect for age, $F(1, 25) = 3.04, p > .05$, or an interaction between age and ABAS-II Teacher domains, $F(2, 50) = 1.39, p > .05$. These findings were not found to support the hypothesis that the Social Domain would represent a particular area of weakness.

Hypothesis 1: EF as Measured by the WMTB-C and D-KEFS

Deficits will be observed across all EF tasks employed; however, deficits on certain EF measures may be more pronounced than on others.

To address statistical differences between the sample mean and the normative mean, one-sample *t*-tests, using the standard error of the sample mean, were employed. Mean performance on the Verbal Fluency–Category Switching Total Switching Accuracy scaled score was at the high end of the low average range and differed from the normative mean of 10, $t(37)= -4.22, p < .05$. Performance on the Design Fluency–Switching score did not differ from the normative mean of 10, $t(37)= -1.93, p > .05$, and the mean standard score fell in the average range. The Color Word Interference Test: Inhibition Total Errors score was selected as a measure of inhibition and performance on this fell in the low average range, and differed from the normative mean of 10, $t(35)= -4.71, p < .05$. Participants showed no deficits on the Tower Test Total Achievement Score as the mean score fell in the average range and did not differ from the normative mean of 10, $t(37) = -1.30, p > .05$.

The mean Listening Recall standard score fell at the low end of the average range and differed significantly from the normative mean of 100, $t(37)= -3.14, p < .05$. In comparison, performance on the Counting Recall subtest was both clinically low and statistically significant, with a mean standard score at the low end of the low average range, and a significant difference from the normative mean of 100, $t(37) = -6.64$, $p < .05$. Despite the original hypothesis, global deficits across all EF tasks were not observed. However, there was some evidence that greater deficits were apparent on some of the EF tasks employed.

Hypothesis 2

The CAS Full Scale Composite score and the CAS Component scores will significantly correlate with more EF scores, as derived from the D-KEFS and WMTB-C, than will the WISC-IV Full Scale score or the WISC-IV index scores.

Prior to exploring this hypothesis, the correlations among WISC-IV scores, among CAS scores, between WISC-IV and CAS scores, and among EF scores were analyzed. These analyses were conducted to assess relations among composite scores within and across the two comprehensive intelligence test batteries. Correlations among EF scores were computed to assess whether EF tasks thought to tap particular EF abilities were more strongly related than those thought to measure different EF abilities. The results are presented below.

WISC-IV Correlations

The correlations among WISC-IV index scores can be seen in Table 9. Aside from a non-significant relation between the Working Memory Index and the Perceptual Reasoning Index, all other WISC-IV index scores correlated positively and significantly with one another. The strongest correlations were found between the WISC-IV FSIQ and index scores.

CAS Correlations

Correlations among CAS component scores and the CAS FS score are also shown in Table 9. Perhaps more in line with the notion of the fractionation of intelligence, there are several non-significant relations among CAS component scores. All CAS components were found to correlate significantly with the overall CAS FS, with the lowest correlation evident between the Simultaneous Processing score and the CAS FS.

Comparisons of WISC-IV and CAS

Correlations across WISC-IV and CAS index and full-scale scores are also presented in Table 9. The WISC-IV index scores and CAS FS score correlated positively. Aside from the Simultaneous Processing Component score, all other CAS component scores correlated positively with the WISC-IV FSIQ. A paired samples *t*-test comparing the WISC-IV FSIQ ($M = 81.46$, $SD = 10.66$) and the CAS FS ($M = 85.86$, $SD = 10.64$) revealed a significant difference, $t(36) = -2.97$, $p < .05$. As the WISC-IV FSIQ was derived using Canadian normative data, whereas the CAS FS score was based on American normative data, and given the differences in performance across Canadian and American children on the WISC measures (PsychCorp, 2003), the WISC-IV scores were recalculated using American norms to allow for a more direct comparison. The resulting WISC-IV FSIQ ($M = 84.19$, $SD = 11.76$) increased 2.73 points. It should be noted that raw score data were not available for one participant who was not administered the WISC-IV, and for another participant for whom the WISC-IV results were obtained from

Table 9

Intercorrelations Between EF Subtests and WISC-IV and CAS Scores

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Listening Recall	___															
2. Counting Recall	.33*	___														
3. Verbal-Switch	.25	.33*	___													
4. Design-Switch	.40*	.39*	.43**	___												
5. Color Word[a]	.24	.05	-.12	.13	___											
6. Tower Test	.02	.20	-.10	.11	.28	___										
7. WISC-IV VCI	.27	.16	.44**	.20	-.11	.05	___									
8. WISC-IV PRI	.28	.26	.30	.48**	.30	.26	.37*	___								
9.WISC-IV WMI	.18	.08	.16	.44**	.17	.31	.39*	.15	___							
10. WISC-IV PSI	.25	.21	.24	.60**	.45**	.35*	.33*	.49*	.38*	___						
11. WISC-IV FSIQ	.34*	.21	.43**	.58**	.25	.30	.77**	.72**	.62**	.72**	___					
12. CAS Planning	.06	.20	.11	.26	.05	.35*	.31	.30	.29	.49**	.47**	___				
13. CAS Simultaneous	.32*	.31	.05	.13	.10	.34*	.27	.40*	.02	.00	.26	.15	___			
14. CAS Attention	.37*	.22	.30	.43**	.40*	.28	.31	.37*	.31	.59**	.53**	.67**	.08	___		
15. CAS Successive	.30	.15	.29	.39*	.06	.15	.36*	.20	.69**	.24	.50**	.31	.10	.40*	___	
16. CAS FSIQ	.42**	.36*	.29	.43**	.24	.40*	.46**	.45**	.50**	.47**	.64**	.73**	.52**	.75**	.70**	__

Note. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full Scale Intellectual Quotient. For WISC-IV correlations n = 37. [a] n = 35 due to administration recording error. For CAS Correlations n =38. [a] n = 36 due to administration recording error *$p < .05$ (2-tailed). ** $p < .01$ (2-tailed) a previous psycho-educational assessment; thus the recalculated WISC-IV FSIQ included only 36 of the 38 participants. Following the recalculation of the WISC-IV FSIQ, another paired samples *t*-test that compared the WISC-IV FSIQ (based on American norms) and the CAS FS was conducted and revealed that the difference between composite scores was no longer significant, $t(35) = 1.07$, $p > .05$.

EF Correlations

The zero-order correlations among the six EF measures employed were generally low to moderate (.43 or lower) (see Table 9). EF tasks thought to measure Set Shifting and Working Memory were found to correlate positively; however, the two tasks chosen to measure Inhibition were unrelated. Listening Recall and Counting Recall, two purported measures of Working Memory, correlated significantly, $r(36)= .33$; $p < .05$. Verbal Fluency–Category Switching and Design Fluency–Switching, two measures of Set Shifting, were also found to correlate, $r(36)= .43$; $p < .05$. The Color Word Interference Test: Inhibition Errors score and the Tower Test were used as measures of Inhibition; results did not reveal a significant correlation between these two tasks. Although tasks were found to correlate for Set Shifting and Working Memory, some tasks within these areas also correlated significantly, and to the same extent, with tasks outside of their supposed target executive function, indicating that the external consistency between target areas was comparable to the internal consistency within a given area. This finding may suggest that the tasks chosen to tap each target executive function may have tapped an underlying EF ability, more so than separable EF abilities. Of the EF tasks administered, the Design Fluency–Switching task was found to correlate with the greatest number of EF tasks (three of five possible), while the Tower Test was not found to correlate with any of the other EF measures administered.

Age has been shown to be related to performance on EF tasks (Klenberg, Korkman, & Lahti-Nuuttila, 2001; Zelazo & Muller, 2002), and specifically as this relates to EF in children and adolescents with FASD (Mattson et al., 1999; Rasmussen & Bisanz, 2005, October). Of the scores derived from the six EF measures administered in the current study, age was found to correlate positively with the standardized score on Listening Recall, $r(36) = .35$, $p < .05$, where level of performance increased with age, and negatively with the standardized score on the Tower Test, $r(36) = -.35$, $p < .05$, where performance decreased with age.

Hypothesis 2: EF, WISC-IV and CAS

Bivariate correlations were used to measure associations between EF scores and composite scores derived from both the WISC-IV and the CAS (see Table 9). For the most part, correlations between EF tasks and WISC-IV and CAS composite scores were low to moderate ($r \leq .60$). Findings revealed significant correlations between the WISC-IV FSIQ and three of the six EF measures of interest (Listening Recall; Verbal Fluency–Category Switching; Design Fluency–Switching). To gain a better understanding of what might be driving the associations between individual EF measures and the overall WISC-IV FSIQ, relations among these EF measures and WISC-IV index areas were explored. Listening Recall test only correlated significantly with the FSIQ, and not with the individual indices of the WISC-IV. Beyond the correlation with the FSIQ, the Verbal Fluency–Category Switching test was found to correlate with the verbal component of the WISC-IV (Verbal Comprehension Index). Given the verbal nature of the Verbal Fluency task, this association was not surprising. Finally, the association between the Design Fluency–Switching score and the WISC-IV FSIQ appeared to be influenced by significant relations among this test and three of the WISC-IV indices (PRI, WMI, and PSI). The Design Fluency task might be described as a visual, time dependent task, that is, to some extent taxing on one's memory resources. As such, the relations observed between this task and the WISC-IV indices might be considered consistent.

Correlations were also found between the CAS FS and four of the six EF measures of interest (Listening Recall; Counting Recall; Design Fluency–Switching; and the Tower Test) (see Table 9). Somewhat surprisingly, Listening Recall correlated with the Simultaneous Processing Component and the Attention Component, but not with the Successive Processing Component – that area where one might logically expect to see a connection given the similarities in activities involved across tests. Although Counting Recall was found to correlate with the CAS FS, it did not correlate with any of the individual CAS components. The Design Fluency–Switching test correlated with both the CAS Attention Component and the Successive Processing Component. Finally, as might be anticipated given the nature of the Tower Test as a visual task often times aligned with planning abilities, this test correlated with both the Simultaneous Processing Component and the Planning Component of the CAS.

The CAS FS did correlate with several EF measures. Surprisingly, several EF measures were also found to correlate with the WISC-IV FSIQ. Interestingly, a look at the correlations across the individual index and component scores derived from the WISC-IV and CAS did not strongly suggest that the EF component of either test (i.e., WISC-IV WMI or CAS Planning) was particularly salient in explaining the correlations between individual EF scores and the overall full-scale scores derived from these measures. That is, it does not appear that the WISC-IV Working Memory Index or the CAS Planning Component is what necessarily drove the relations found between individual EF scores and the overall full-scale scores.

Hypothesis 3

Compared with the WISC-IV and individual EF scores, the CAS and specifically the Planning and Attention Components of the CAS will be better predictors of adaptive behaviour as assessed by the ABAS-II.

Prior to exploring this hypothesis directly, the relations between the ABAS-II Parent and Teacher Forms were analyzed to assess the consistency between parent and teacher ratings of adaptive behaviour.

Comparisons Across ABAS-II Parent and Teacher Forms

For the 27 participants with both parent and teacher data, correlations across ABAS-II Parent and Teacher forms skill areas and domain composites were conducted and results are shown in Table 10. Interestingly, findings revealed no correlations between parent and teacher ratings of participants' adaptive skills. Paired samples *t*-tests were conducted on each of the domains (i.e., Conceptual, Social, Practical) and the Global Adaptive Composite (GAC) domain across parent and teacher forms (means in Table 5). Across all domains and the GAC, means were lower for parents' scores than for teachers' scores, $ts\ (26) \geq -2.90$, $ps < .05$.

Hypothesis 3 Analyses

Four separate hierarchical regression analyses were conducted in the prediction of the ABAS-II Parent GAC and in the prediction of the ABAS-II Teacher GAC. For each analysis, age, gender, and ethnicity were included in the first step. The order of all subsequent steps is outlined as each analysis is described. For significant overall models, the individual unstandardized beta coefficient, the standard error, the standardized beta coefficients, and the R^2 change at each step are provided.

Predicting ABAS-II Parent Form GAC. To address the hypothesis that the CAS FS would be a better predictor of adaptive behaviour than would the WISC-IV FSIQ, a hierarchical regression analysis was conducted to examine the relative contribution of various child-related factors (i.e., age, gender and ethnicity), the WISC-IV FSIQ and the CAS FS in accounting for unique variance in the ABAS-II Parent GAC. The overall model that included demographic variables, the WISC-IV FSIQ, and the CAS FS was not significant, $F(5, 31) = .13, p > .05$ ($R^2 = .02$). After controlling for age, gender, and ethnicity, neither the R^2 change (.02) associated with WISC-IV FSIQ nor the R^2 change (.00) associated with the CAS FS was significant.

To examine whether the CAS component scores (i.e., Planning, Simultaneous Processing, Attention, Successive Processing) would account for unique variance beyond that explained by the WISC-IV FSIQ, a hierarchical regression analysis was conducted with the ABAS-II Parent GAC as the criterion variable. Age, gender and ethnicity were entered together as a first step in the regression equation, followed by the WISC-IV FSIQ

Table 10

Intercorrelations Between ABAS-II Parent and Teacher Scores

Measure	1.	2.	3.	4.	5.	6.	7.	8.
1. Parent – Conceptual	____							
2. Parent – Social	.83**	____						
3. Parent – Practical	.84**	.87**	____					
4. Parent – GAC	.93**	.93**	.95**	____				
5. Teacher – Conceptual	.14	.09	-.17	-.03	____			
6. Teacher – Social	.16	.18	-.14	.03	.86**	____		
7. Teacher – Practical	.18	.19	.01	.11	.87**	.77**	____	
8. Teacher – GAC	.20	.21	-.07	.08	.95**	.92**	.94**	____

Note. df = 25

*$p < .05$ (2-tailed). ** $p < .01$ (2-tailed)

and the CAS component scores (see Table 11). Unlike the results for the CAS FS, the CAS component scores were found to significantly contribute to the model, resulting in a significant overall model, $F(8, 28) = 3.06, p < .05$ that accounted for 47% of the total variance in the ABAS-II Parent GAC. As can be seen in Table 11, the R^2 changes associated with Models 1 and 2 were not significant, however, the R^2 change associated with the addition of the CAS components was significant. Significant semi-partial correlations between both the CAS Planning Component and the Attention Component with the ABAS-II Parent GAC suggested that these variables were likely most responsible for a significant overall model. A somewhat surprising finding involved the direction of the semi-partial correlation between the CAS Attention Component and the ABAS-II Parent GAC. Whereas the Planning Component was positively correlated with this criterion variable as might be anticipated, the Attention Component was negatively correlated. This finding may be a function of what is termed suppression. A negative

Table 11

Summary of Hierarchical Regression Analysis for Variables Predicting Parent ABAS-II GAC

Variable	Parent Form n = 38			
	B	*SE B*	ß	R^2 *Change*
Step1				.00
Age	.00	.09	.00	
Gender	1.86	6.17	.05	
Ethnicity	.52	6.80	.01	
Step 2				.02
Age	.01	.09	.02	
Gender	2.41	6.27	.07	
Ethnicity	.84	6.86	.02	
WISC-IV FSIQ	.21	.30	.13	
Step 3				.45**
Age	.08	.08	.15	
Gender	5.02	5.19	.14	
Ethnicity	-4.58	5.76	-.12	
WISC-IV FSIQ	.29	.31	.18	
Planning	13.60	2.93	.91**	
Simultaneous	-.19	.22	-.13	
Attention	-11.31	3.08	-.77**	
Successive	-.03	.25	-.02	

Note. *p < .05; **p < .01 .

suppression variable is defined by Darlington (1968) and described by Henard (1998) as a variable with a near zero correlation with the criterion variable, which receives a negative weight when included in a regression equation with other predictor variables that correlate positively with the criterion. In line with this, in the current study, the zero-order correlation between Attention and ABAS-II Parent GAC was -.09 (near zero), and the beta weight of the Attention variable was -.77. When the partial correlation is higher than the original zero-order correlation, this can also indicate suppression (Garson, 2007). This appears to be the case with Attention where the partial correlation (-.57) was much higher than the zero-order correlation. Suppression can sometimes occur when predictor variables are themselves correlated (Horst, 1966), and again this seems to apply here where Attention was highly correlated with the Planning Component. Despite the near zero correlation between Attention and parent-rated adaptive behaviour, it appears that by suppressing irrelevant variance in the Planning Component (Glass & Hopkins, 1996), the Attention Component in effect improved the predictive efficiency of Planning and the overall multiple regression. Whereas the zero-order correlations between the CAS Attention Component and the ABAS-II Parent Domain scores, including the GAC, were non-significant, the zero-order correlations between the Planning Component and the ABAS-II Parent domains indicated significant associations across all parent rated domains (see Table 12).

To investigate whether the WISC-IV index scores (i.e., VCI, PRI, WMI, and PSI) might account for unique variance in adaptive behaviour beyond that explained by the CAS FS, a hierarchical regression analysis was conducted with the ABAS-II Parent GAC as the criterion variable. Like the previous analysis, age, gender and ethnicity were entered in the first step of the equation, followed by the CAS FS, and then the WISC-IV index scores. Unlike the results for the CAS components, the WISC-IV index scores were not found to significantly contribute to the prediction of parent-rated adaptive behaviour. The overall model that included demographic variables, CAS FS and WISC-IV index scores was not significant, $F(8, 28) = .14$, $p > .05$. Furthermore, the R^2 change statistics associated with each step in this 3-step model were not significant, nor were the semi-partial correlations between each of the WISC-IV index scores and the criterion variable. As can be seen in Table 12, zero-order correlations between the WISC-IV and all ABAS-II Parent Form domains were not significant.

Finally, to assess whether individual EF scores derived from EF tools (i.e., WMTB-C and D-KEFS) thought to measure various aspects of EF, would predict adaptive behaviour, all 6 EF scores were included in a regression equation with ABAS-II Parent GAC as the criterion variable. After controlling for age, gender and ethnicity, the 6 EF scores were entered in Step 2. The overall model was not significant $F(9, 26) = 1.35$, $p > .05$, nor was the R^2 change (.30) associated with the addition of the EF scores in the model. Of the six semi-partial correlations computed for each of the EF scores with the ABAS-II Parent GAC, only those involving the Tower Test (semi-partial $r = .36$) and the Color Word Interference Test (semi-partial $r = -.38$) were significant. Zero-order correlations between the ABAS-II and the EF scores are presented in Table 12.

Table 12

Intercorrelations Between the ABAS-II Parent and Teacher Forms and the CAS, WISC-IV, and EF Measures

	P-Conceptual	P-Social	P-Practical	P-GAC	T-Conceptual	T-Social	T-Practical	T-GAC
Planning	.40*	.33*	.39*	.40*	-.04	-.01	.11	.05
Simultaneous	.14	.04	-.09	.00	.48*	.53**	.27	.42*
Attention	-.07	-.15	-.10	-.09	-.05	-.08	.05	-.01
Successive	.09	-.01	-.10	.01	.15	.05	.07	.10
CAS FS	.19	.05	.02	.11	.22	.18	.17	.21
VCI	.25	.04	.11	.13	.15	.07	.05	.11
PRI	.22	-.02	-.04	.06	.38	.30	.35	.37
WMI	.02	-.01	.02	.04	.04	.01	.10	.06
PSI	.14	.05	.09	.12	.12	.12	.31	.24
WISC-IV FSIQ	.23	.01	.06	.12	.23	.15	.26	.25
Listening Recall	-.13	-.34*	-.30	-.25	.24	.09	.29	.19
Counting Recall	.04	-.05	-.02	.05	.22	.08	.15	.12
Verbal - Switch	.15	-.02	.08	.09	.15	-.07	.18	.10
Design - Switch	.07	-.10	-.07	.01	.09	-.06	.17	.09
Color Word	-.32	-.30	-.36*	-.35*	-.08	-.03	-.06	-.07
Tower Test	.23	.24	.15	.22	.37	.39*	.49*	.43*

Note. P = Parent; T = Teacher; GAC = Global Adaptive Composite; CAS FS = CAS Full Scale Composite; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full Scale Intellectual Quotient. *df* ABAS-II Parent Form = 36 ; *df* ABAS-II Teacher Form = 25; *p < .05(2-tailed); **p < .01 (2-tailed).

These findings offer some support for the hypothesis that the CAS would offer a better predictor of parent-rated adaptive behaviour than the WISC-IV or individual EF measures. Although the CAS FS was not found to explain any unique variance beyond that explained by the WISC-IV FSIQ, both the Planning and Attention Components of the CAS were found to significantly contribute to the prediction of adaptive behaviour.

Predicting ABAS-II Teacher Form. Applying the same approach as that used in the prediction of parent-rated adaptive behaviour, a hierarchical regression analysis was conducted to examine the relative contribution of various demographic variables (i.e., age, gender and ethnicity), the WISC-IV FSIQ, and the CAS FS in accounting for unique variance in the ABAS-II Teacher GAC. The overall model including demographic variables, the WISC-IV FSIQ, and the CAS FS was not significant, $F(5, 20) = 2.43$, $p > .05$. Whereas the R^2 change (.32) associated with the demographic variables was significant, the R^2 change associated with the WISC-IV FSIQ (R^2 change = .05) and the CAS FS (R^2 change = .00) was not. Significant semi-partial correlations associated with the three variables entered in Step 1 suggested that age (semi-partial r = -.47), gender (semi-partial r =.38) and ethnicity (semi-partial r =.37) all accounted for unique variance in teacher-rated adaptive behaviour, where younger students, males, and Aboriginal students were found to have higher adaptive skill ratings.

To assess whether CAS component scores (i.e., Planning, Simultaneous Processing, Attention, Successive Processing) might contribute to the prediction of the ABAS-II Teacher GAC, beyond that provided by the WISC-IV FSIQ, a 3-step hierarchical regression was conducted. To start with, age, gender and ethnicity were entered together as a first step in the regression equation. This was followed by the

WISC-IV FS and the CAS component scores. The overall model was not significant, $F(8, 17) = 2.01, p > .05$. Only the R^2 change associated with the demographic variables was significant.

A hierarchical regression analysis was then performed to assess whether WISC-IV index scores might explain additional variance in the ABAS-II Teacher GAC beyond that accounted for by demographic variables and the CAS FS. The overall model was not significant $F(8, 17) = 1.91, p > .05$, nor was the R^2 change (.13) associated with the inclusion of WISC-IV index scores in the model. Like findings from the ABAS-II Parent GAC, all semi-partial correlations between each of the WISC-IV index scores and the ABAS-II Teacher GAC were non-significant.

Finally, to assess whether EF scores derived from the WMTB-C and the D-KEFS would be predictive of adaptive behaviour, these variables were included in a regression equation with the ABAS-II Teacher GAC as the criterion. After controlling for age, gender and ethnicity, six EF scores were entered in Step 2. The overall model was not significant, $F(9, 15) = 2.47, p > .05$, nor was the R^2 change (.27) associated with the EF scores in the model. Of the semi-partial correlations calculated, only that associated with Listening Recall was significant (semi-partial r =.36).

These findings were inconsistent with the hypothesis that the CAS, and particularly the EF affiliated components of the CAS, would help in the prediction of teacher-rated adaptive behaviour. Rather, it appears that age, gender, and ethnicity were those variables most salient in explaining adaptive behaviour as rated by teachers.

CHAPTER V: DISCUSSION AND CONCLUSIONS

Intelligence tests are often employed when determining eligibility for various services for persons with developmental disabilities (Kranzler, 1997; Reschly, 1997; Ramey & Ramey, 2000), including those with FASD. Based on findings from prior studies in FASD research, where IQ scores, including those derived from Wechsler scales, lack strong predictive validity for real-life outcomes for persons with FASD, this practice has come into question (Streissguth et al., 1996; Thomas et al., 1998). Several researchers have hypothesized that the failure of IQ tests to predict adaptive outcomes may relate to the insensitivity of such tests to EF (Ardila, Pineda, & Rosselli, 2000). Based on the extant literature, EF deficits are thought to be typical in persons with FASD, and are often unrelated to performance on IQ tests (Kodituwakku, Kalberg, et al., 2001; Rasmussen, 2005). Some theorists suggest that EF falls under the domain of intelligence and should thus be included in a measure of intelligence (Friedman et al., 2006). The present study explored the use of two IQ tests with children and adolescents with FASD: the CAS – a test that has, since its initial development, included Planning (an aspect of EF) as a key component in the operationalization of intelligence; and the WISC-IV, which now includes a component of EF, but whose predecessors failed to identify EF as central to the construct of intelligence. Applying Miyake et al.'s (2000) model of EF, six tests of EF, two within each target executive function (i.e, Set Shifting, Working Memory and Inhibition), were employed to examine the relations between performance on relatively lower-order EF tasks with performance on IQ tests and adaptive behaviour measures in children and adolescents with FASD. The primary goals of the study were to compare the usefulness of the two IQ tests in revealing a cognitive profile; to assess the relations amongst EF abilities and between EF abilities and IQ (CAS and WISC-IV); and to compare the WISC-IV, CAS and EF measures in the prediction of parent- and teacher-rated adaptive behaviour scores for a population of children and adolescents with FASD.

The following discussion is organized around the three main hypotheses that guided this study.

Hypotheses

Hypothesis 1

Profile analysis will reveal distinct patterns of functioning on all measures employed (i.e., WISC-IV, CAS, ABAS-II, EF measures).

Hypothesis 1: WISC-IV

Relative to other indices derived from the WISC-IV, profile analysis will reveal particular deficits on the Working Memory Index.

Profile analysis of intelligence test scores is meaningful to the extent that scores accurately represent an individual or group's level of ability across distinct components of intellectual functioning. The mean full-scale IQ generated from the WISC-IV, 81.46, fell in the low average range of functioning. This score appears to be somewhat higher than that reported in various other FASD studies (for review, see Mattson & Riley, 1998); however, it does seem to be in line with results from a large scale study of children and adults with FASD, where the mean IQ for participants with FAS was 80 and the mean IQ for persons with FAE was 88 (Streissguth et al., 2004). Various researchers have explored the cognitive profile of persons with FASD on the basis of analysis of IQ test performance. Although some results suggest discrepancies across factors (i.e., Verbal IQ and Performance IQ), findings across studies do not support the existence of a consistent pattern of strengths or weaknesses on some of the most popular IQ tests used (Mattson & Riley, 1998). The WISC-IV, which was employed in this study, is the most recent version of the Wechsler intelligence scale for children, and although there is some overlap and consistency between this test and its predecessor, the WISC-III, the inclusion of new subtests, along with a redefined factor structure, makes difficult the comparison of findings from the current study to those of earlier studies where previous versions of the WISC were employed.

In the current study a profile emerged on the WISC-IV. As hypothesized, the Working Memory Index had the lowest overall mean score and was lower than two of the three other indices (Verbal Comprehension and Perceptual Reasoning). The Perceptual Reasoning Index had the highest overall mean score and was higher than two of the three other indices (Working Memory and Processing Speed). Particular deficits in the area of Working Memory are not surprising despite relatively limited research exploring this particular aspect of EF in children with FASD (Burden et al., 2005; Carmichael Olson et al., 1998; Rasmussen, 2006). EF deficits specific to working memory have been found in children with FASD, and this area of weakness is thought to account, in part, for specific deficits in arithmetic (Rasmussen, 2006). The new WISC-IV Working Memory factor includes two subtests, one old (Digit Span) and one new (Letter-Number Sequencing). Based on results of previous studies that describe subtest level analysis on the Wechsler scales, there is some indication that the Digit Span subtest is one of the WISC subtests presenting the greatest difficulties for children exposed to alcohol in uterus (Shaywitz, Cohen, & Shaywitz, 1980; Streissguth et al., 1996). Unlike some previous studies where discrepancies between Verbal and Performance areas were found (for review see Mattson & Riley, 1998), in the present study a difference was not found between the Verbal Comprehension Index and the Perceptual Reasoning Index, those areas most closely aligned with the previously divided Verbal IQ and Performance IQ areas.

Hypothesis 1: CAS

Profile analysis of scores derived from the CAS will reveal the Planning Component (aligned with EF) as a particular area of cognitive limitation.

The cognitive profile of participants on the CAS was a specific focus of this study. The overall mean score achieved on the CAS was 85.89. This score is consistent with findings from the only other study known to employ the CAS with this population, where children and adolescents obtained a mean standard score of 84.6 (Mackey, 2000). In line with the original hypothesis, profile analysis across CAS components revealed particular deficits in the area of Planning where the mean Planning score differed significantly from two of the three other cognitive areas (Simultaneous Processing and Attention). The mean Simultaneous Processing score had the highest overall mean score and differed significantly from the Planning Component and Successive Processing Component. These findings are somewhat congruent with the findings of Mackey's (2000) smaller-scale study using the CAS with 20 children (aged 6 to 13 years) with FAS and FAE. A similar strength/weakness profile emerged with Planning as the lowest component and Simultaneous Processing as the highest component. However, unlike findings from the current study, Mackey (2000) also found significant differences between the Planning Component and the Successive Processing Component, and between the Simultaneous Processing Component and the Attention Component.

The Planning Component of the CAS is aligned with EF and tasks contributing to this score arguably tap multiple EF abilities. Successful performance on both Planning subtests are likely dependent on what Luria would describe as programming, regulation, and verification of an activity—three steps also implicated in Norman and Shallice's Supervisory Attentional System and novel problem-solving paradigm. Based on subtest and composite scores alone, it is difficult to establish at what level of the problem-solving model that errors occurred. As discussed earlier, in the standardization process of the CAS, the CAS Planning Component and the Attention Component were found to load together. In the current study, these components were also found to be highly correlated with one another, however, significant differences in performances across these two areas lends further evidence to the argument that planning and attention are two interwoven, yet distinct constructs (Lyon & Krasnegor, 1996).

Hypothesis 1: ABAS-II Parent and Teacher Forms

Profile analysis of scores derived from the ABAS-II Parent and Teacher forms will reveal the Social Domain as a particular area of adaptive weakness.

Consistent with findings from previous studies where adaptive behaviour deficits are frequently reported for persons with FASD, both parents and teachers in the current study endorsed items that suggest limitations in the adaptive functioning for most participants. Although mean scores suggest an overall deficit in the area of adaptive functioning for this group, analysis of individual level data indicate that some participants were rated as having adaptive behaviour skills commensurate with same aged peers.

Somewhat incongruent with the original hypothesis and with findings from previous studies that converge to suggest particular deficits in the area of social functioning of persons with FASD, are scores from the ABAS-II Parent Form in the current study that indicate that the Social Domain, relative to the Conceptual and Practical Domains, represents the strongest area of adaptive functioning for this sample, followed by the Practical Domain and the Conceptual Domain. Interestingly, after controlling for age, adaptive domains as rated by teachers were not found to differ. Across both parent and teacher forms the skill area of self-direction, falling under the Conceptual Domain, represented that skill area with the lowest score. Self-direction is said to assess participants' levels of independence, responsibility and self-control—abilities that might also be aligned with higher order EF.

Comparisons of these findings with those of previous investigations is somewhat constrained given the differences between tools employed in the current study with those used in others. To date, no previous studies exploring adaptive behaviour in persons with FASD have employed the ABAS-II, and thus inconsistencies between the operationalization of adaptive domains between this test and others may explain the divergent findings of the current study. The ABAS-II is a relatively new measure of adaptive behaviour and was chosen because of its reported clinical utility and in light of existing information regarding relations between this measure and the WISC-IV. The Vineland Adaptive Behavior Scale appears to be the most commonly used adaptive behaviour scale reported in previous FASD literature (Streissguth et al., 1996; Thomas et al., 1998; Whaley et al., 2001) and a validity study conducted with this and the ABAS-II indicate moderately high correlations between the global scores and adaptive domains scores obtained on either test (Harrison & Oakland, 2003, p. 124).

Hypothesis 1: EF as Measured by the WMTB-C and D-KEFS

Deficits will be observed across all EF tasks employed; however, deficits on certain EF measures may be more pronounced than on others.

Somewhat surprising were the relatively high scores achieved on some of the EF measures chosen. Children performed significantly below the normative mean on all EF tasks except the D-KEFS Design Fluency–Switching and the Tower Test. However, in terms of clinical interpretation of performances, mean scores on only three of the six EF tests fell below the average range. This finding suggests that for many participants, performance on these EF tasks would likely be interpreted by clinicians as consistent with most other children of their age. As hypothesized, participants performed poorer on certain EF tasks than on others. Within the following section, individual EF test results are compared with findings of previous research using the same or comparable measures.

Working memory. Based on a review of the literature, it appears that the WMTB-C has been used in only one reported FASD study (Rasmussen, 2006). Within the current study, the Listening Recall and Counting Recall subtests of the WMTB-C were used as measures of working memory. Although mean scores on both of these subtests differed significantly from the normative mean, on only the Counting Recall test were scores seen to fall below the average range. The lower score achieved on the Counting Recall test is consistent with that of Rasmussen (2006) who also found low scores on this test in her sample of 4- to 8-year-old children with FASD.

Set shifting. Various verbal fluency tasks have been employed in the assessment of children, adolescents and adults with FASD (Bookstein et al., 2002; Connor et al., 2000; Kerns et al., 1997; Kodituwakku et al., 1995; Kodituwakku et al., 2006; Mattson &

Riley, 1999; Noland et al., 2003; Schonfeld et al., 2001; Rasmussen & Bisanz, 2005, October). The D-KEFS Verbal Fluency test, which includes a measure of verbal shifting, has been employed in two of these reported studies (Rasmussen & Bisanz, 2005, October; Schonfeld et al., 2001). Within the current study, Verbal Fluency–Category Switching was the variable of interest. Findings revealed that the performance of participants on this condition was lower than the normative mean, with a score falling in what would be described clinically as the low average range. These findings are perhaps consistent with findings from these previous studies where deficits were noted on this task relative to controls (Schonfeld et al., 2001) and when comparing scores against normative data (Rasmussen & Bisanz, 2005, October). Like Rasmussen and Bisanz, category shifting scores were found to fall at the higher end of the low average range and were not related to age.

Nonverbal fluency tasks are frequently reported in the FASD literature (Bookstein et al., 2002; Connor et al., 2000; Kerns et al., 1997; Schonfeld et al., 2001; Rasmussen & Bisanz, 2005, October). Specifically, the D-KEFS Design Fluency Test has been employed in two of these FASD studies (Rasmussen & Bisanz, 2005, October; Schonfeld et al., 2001). Consistent with findings from Rasmussen and Bisanz (2005, October) the Design Fluency–Switching score did not differ from the normative mean and an average score on this nonverbal fluency task indicates normal functioning. This finding may be considered somewhat incongruent with findings of Schonfeld et al. (2001) who reported deficits on this task relative to controls. In their study, the control group and FASD groups were not matched on cognitive functioning, making it difficult to establish whether differences noted between groups were in fact a function of EF or some other confounding non-EF related ability. In that standard scores were not the focus of analyses in the Schonfeld et al. (2001) study, the performance of participants relative to the normative sample cannot be determined.

Inhibition. The Color Word Interference test from the D-KEFS battery has been used in three previously reported FASD studies (Mattson et al., 1999; Rasmussen & Bisanz, 2005, October; Schonfeld et al., 2005). The results of the current study may be interpreted as consistent with findings from two of these prior studies, where deficits were determined on the basis of comparison to controls (Mattson et al., 1999) and on the basis of normative data (Rasmussen & Bisanz, 2005, October). Schonfeld et al. (2005) found this test of inhibition to be a significant predictor of moral maturity in children and adolescents with FASD; however, task performance was not reported. The D-KEFS offers several primary and optional scores, of which the current study focused on one: the Color Word Interference Test - Inhibition Error Scaled Score. Specific information on this score was not reported in the reviewed studies, making it difficult to draw direct comparisons. The Color-Word Interference Test is based on the original Stroop task. The Stroop task and variations on this task, excluding that within the D-KEFS, have been employed in other FASD studies (Bookstein et al., 2002; Burden et al., 2005; Connor et al., 2000). Connor et al. (2000) focused on errors made on the Stroop and found that the number of errors made during the interference task was in line with what would be expected based on regression-based IQ. Based on overall results on this task, the authors concluded that performance on the Stroop task was uninformed by an FAS diagnosis.

Variations on the tower test have been employed in several FASD studies (Kodituwakku et al., 1995; Mattson et al., 1999; Korkman et al., 2003; Rasmussen &

Bisanz, 2005, October), with the D-KEFS Tower Test being used in two of these studies (Mattson et al., 1999; Rasmussen & Bisanz, 2005, October). Consistent with findings from Rasmussen and Bisanz (2005), the D-KEFS Tower Test Achievement mean score in the current study did not differ from the normative mean, nor did it fall outside of the average range of functioning. The focus of analysis in the current study differed from Mattson et al. (1999), in that they looked more specifically at rule violations and total number of items passed on the D-KEFS Tower Test across alcohol exposed groups and controls. Although these researchers found significantly more rule violations in both alcohol exposed groups relative to controls, a non-significant group difference between alcohol exposed and non-exposed participants on number of Tower Test items passed might be considered in line with findings reported here, as total number of items passed contributes to overall Tower Test Achievement Score, the focus of analysis in the present study.

An interesting finding and one that would warrant further examination involves how examinees tended to perform better on EF tasks that were more highly dependent on nonverbal abilities, than on tasks that were more dependent on verbal abilities. That is, of the EF tasks administered, it appears that examinees in the present study performed best on the two tasks that were most dependent on perceptual abilities and least dependent on verbal abilities (i.e., Design Fluency and the Tower Test).

Hypothesis 2

The CAS Full Scale Composite score and the CAS Component scores will be more highly correlated with EF scores derived from the D-KEFS and WMTB-C than will the WISC-IV Full Scale score or WISC-IV Index scores.

Comparisons of WISC-IV and CAS

Prior to examining the relations between EF and the two tests of intelligence employed, the relation between the WISC-IV and the CAS was explored, and the relations among EF measures themselves were also explored. A comparison of the CAS FS with the WISC-IV FSIQ revealed a statistically significant difference, where examinees' mean score on the CAS was higher than that obtained on the WISC-IV. As described earlier, this discrepancy was most likely a function of the difference in normative data used to score either test. Whereas Canadian normative data were used to score the WISC-IV, Canadian norms are not available for the CAS, and for this reason U.S. norms were applied. Previous studies comparing U.S. and Canadian children's performances on IQ tests indicate that Canadian children, relative to their American neighbours, tend to perform somewhat better on tests of intelligence, with, for example, a 2.4 point difference favouring Canadians on the WISC-IV standardization data (PsychCorp, 2003). Consistent with this, was the finding in the current study where the composite FSIQ score derived from applying American as opposed to Canadian norms on WISC-IV raw scores resulted in a 2.73 point increase. Another possible explanation for the superior performance on the CAS may involve the differences in types of subtests included in either battery. For example, relative to CAS subtests, a greater number of WISC-IV subtests are more dependent on verbal abilities. In that a majority of the participants within the current study reported an Aboriginal background, and given findings from previous studies that indicate lower performance on verbal as compared to nonverbal cognitive tests for Aboriginal children (Rasmussen, Baydala & Sherman, 2004), the heavier verbal demands of the WISC-IV as compared to the CAS subtests, may help to explain the somewhat weaker performance on the WISC-IV. Although performance on the WISC-IV indices was not found to differ between Aboriginals and non-Aboriginals, it is possible that within-group variability in the Aboriginal group may have attenuated a relation that might have otherwise been seen if living context had been concurrently considered. That is, whereas several participants who reported an Aboriginal background were being reared by non-Aboriginals, presumably within the dominant culture, there were several others who were living within a more traditional Aboriginal context, where a focus on nonverbal thinking abilities may have been more relevant.

EF Correlations

To explain limitations in adaptive and maladaptive functioning in persons with FASD, some researchers have pointed to deficits in EF (Connor et al., 2000; Mattson et al., 1999). Previous studies that have explored EF abilities in persons with FASD have generally employed a large range of lower order and complex EF tasks, often without any theory guiding how the construct of EF should be defined, or what tools might be most appropriate for its measurement. Within the current study, an effort was made to choose generally lower-order EF tasks that target three often postulated EF abilities, identified on the basis of factor analytic findings that support the presence of three separable, but related EF areas (Friedman et al., 2006; Miyake et al., 2000; Lehto et al., 2003). A connection was made between these three areas of EF and Norman and Shallice's Supervisory Attentional System and novel problem-solving paradigm. To explore the relations among EF tasks chosen for this study, simple correlations were calculated within and across the three target EF areas. To begin with, zero-order correlations across the two EF tasks thought to tap each of the three EF target areas were computed. Across two of the three target EF areas (i.e., Set Shifting and Working Memory), tasks were found to moderately correlate; however, in the area of Inhibition, the chosen tasks did not correlate.

The lack of a relation between the Tower Test and the Color-Word Interference Test-Inhibition, two tests used to operationalize Inhibition, may relate in part to the strategy application in solving the Tower Test, or to the nature of the Tower Test as a complex, as opposed to lower order, EF task. Miyake et al. (2000) argue as to why a tower test might, in the first place, be considered a measure of inhibition. Although this task is often said to fall under the domain of planning, the assumption here is that a planning related strategy is employed to solve the puzzle. The goal-recursive strategy (Carpenter, Just, & Shell, 1990), which involves extensive goal management and various sub-goals carried out to achieve a superordinate goal, involves planning and has been linked with successful performance on the Tower of Hanoi puzzle. An alternative, less complex, perceptual strategy has also been linked with this task and some research suggests that examinees tend to adopt this strategy over more planning dependent strategies when solving the puzzle (Goel & Grafman, 1995). Whereas the goal-recursive strategy is strongly aligned with planning ability, the perceptual strategy is thought to relate to inhibition, as examinees must stop their prepotent responses and engage in counterintuitive moves—moves that involve transfer of a disk in the direction opposite to that of the end goal—to achieve the desired position. It is possible that participants within this study favoured the goal-recursive strategy over the perceptual strategy in solving the Tower Test, and for this reason, the Tower Test did not correlate with the more inhibition dependent Color-Word Interference Test. In that scores from the Tower Test correlated significantly with those on the CAS Planning Component, there is some support for the notion that examinees may have employed a planning related strategy in solving the Tower Test puzzle. It is also possible that the Tower Test, as a more complex EF task, concurrently tapped multiple EF and non-EF abilities and for this reason remained unrelated to a more automatic inhibition task (Color Word Interference Test).

The finding of moderate, positive correlations of tasks in the areas of Set Shifting and Working Memory might on their own be seen as evidence of separable EF abilities; however in that the same EF tasks correlated significantly and, often to the same extent, with EF tasks outside of their target EF area, there does not appear to be strong support for the idea that chosen tasks tapped separable EF abilities in this sample of children with FASD. Low correlations across multiple EF tasks are commonly reported in EF literature, and factor analytic findings in populations with and without brain damage suggest separable EF factors (see Miyake et al., 2000). Recent factor analytic findings from normal children and adults suggest that interrelated factors of EF support the notion of the unity and diversity of EF. Although Miyake et al. (2000), Lehto et al. (2003) and Friedman et al. (2006) found support for the three separable, but related EF abilities, the smaller sample size in the current study did not allow for specific examination of factors. Based on moderate correlations across EF tasks thought to tap different EF areas, there appears to be some support for an underlying latent EF ability, but not three separable EF abilities. There are several plausible explanations that might account for why the current data do not suggest the presence of separable EF abilities in this population. The failure to find relations might simply relate to an issue of statistical power where the number of participants within this study did not allow us to see relations even though they may exist.

It might also have to do with the types of tasks chosen to operationalize the target EF of interest. Although an effort was made to choose generally lower order EF tasks to avoid the task impurity issue where EF tasks are confounded by non-EF related abilities, this was not necessarily achieved. For example, as previously mentioned, the Tower Test is considered a more complex EF task that concurrently taps and measures multiple EF and non-EF abilities. Whereas most of the tasks chosen were considered relatively lower-order EF tasks, in that they do not typically place heavy demands on non-executive processes, the task impurity of some of the tasks might contribute to the lack of relation or the attenuation of a relation among tasks thought to measure the same EF ability. The lack of relation among EF tasks might also relate to differences between this population and others where separable EF abilities have been found. It is possible that the nature of CNS dysfunction in this population of persons with FASD has implications for task completion, or for the structure of EF itself, and for these reasons we find differences between relations found in this study with those observed in other studies.

The rationale for selecting EF tasks thought to measure separable EF abilities was to allow for an examination of performance across EF areas. If meaningful EF domains could be established, and if performances differed across these domains, then it might be argued that prenatal alcohol exposure has a specific rather than global impact upon EF. As a small sample size did not allow for factor analysis and correlational findings did not support the fractionation of EF abilities on the basis of presumed areas, a meaningful examination of differences across EF areas was not possible. Even if EF in the current study could be divided into three separable areas on the basis of previous research findings, and if the tasks chosen did in fact measure these different areas, an analysis of performances on individual subtests within and across each EF area did not suggest that one area of EF was spared the effects of alcohol exposure more so than another.

EF, WISC and CAS

Correlations were based on composite IQ scores and specific scores derived from EF measures. The WISC-IV FSIQ was moderately correlated with the Listening Recall task and the Verbal Fluency–Category Switching task, with the strongest relation found between the WISC-IV FSIQ and the Design Fluency–Switching task. EF tasks were chosen to target particular EF areas, and based on findings, the relations between EF tasks and IQ do not appear to be consistent with what might be anticipated based on the factor structure of the WISC-IV. That is, although it might be expected that Listening Recall and Counting Recall, two purported measures of working memory, would be more strongly aligned with the WISC-IV, given that working memory represents one of the four cognitive indices on the WISC-IV, such does not appear to be the case. If the measures chosen to target certain EF abilities in the current study are in fact assessing those areas (i.e., Set Shifting, Inhibition, Working Memory), one would conclude, based on the evidence, that Set Shifting appears to be that area of EF most consistently correlated with the WISC-IV FSIQ, despite the apparent lack of set shifting related subtests on the WISC-IV. This finding can be contrasted with those of a recent study (Friedman et al., 2006) that explored the relations between inhibition, updating and set shifting with fluid, crystallized intelligence, and overall IQ as measured by the Wechsler Adult Intelligence Scale (WAIS) in a normal population of young adults. These researchers found updating (working memory) to be that EF most closely related to both fluid and crystallized intelligence, accounting for a relatively large percentage of the intelligence measures' variances.

Unlike the WISC-IV, previous versions of the WISC did not explicitly set out to measure EF abilities. It is plausible that for this reason, EF tasks within the current study were more highly correlated with the WISC-IV. However, in that a closer examination of the correlations between EF measures and WISC-IV indices did not reveal the Working Memory Index to be particularly salient in explaining the associations between EF and WISC-IV FSIQ, this is likely not the only reason why relations between EF and FSIQ were observed in this sample. Using subtests from the D-KEFS, neither Mattson et al. (1999) nor Schonfeld et al. (2001) found correlations between scores derived from earlier versions of the Wechsler scales and those derived from the D-KEFS in children with FASD. Korkman et al. (2003) did however, find relations between NEPSY EF subtests and the WISC-III.

The CAS FS also correlated positively with certain EF measures in the current study. Similar to findings with the WISC-IV, the Listening Recall task and the Design Fluency–Switching task both correlated with the CAS FS. Unlike findings from the WISC-IV, correlations were also noted between the Counting Recall task and the Tower Test with the CAS FS. Whereas Verbal Fluency–Category Switching correlated with the WISC-IV FSIQ, correlations were not observed between this set shifting task and the CAS FS. Based on these results, it appears that Working Memory subtests were most closely aligned with the CAS, relative to Shifting and Inhibition. This relation is consistent with previous research where an association between intelligence and working memory capacity has been found (Engle, Tuholski, Laughlin, & Conway, 1999; Friedman et al., 2006).

Based on the analyses conducted within the current study it is difficult to determine if EF abilities are in line with what would be predicted based on IQ scores. In terms of a clinical interpretation of performance on IQ tests and EF measures, where mean FSIQ scores derived from both the WISC-IV and the CAS fell in the low average range, and mean EF scores fell in both the low average and average ranges, it could be suggested that there does seem to be some congruency between observed EF scores and expected EF scores based on IQ. Two previous studies, employing control and comparison groups, specifically attempted to assess expected EF abilities given IQ scores in adults with FASD (Connor et al., 2000; Kerns et al., 1997). Based on their analyses both groups of researchers concluded that EF was lower than would be predicted based on IQ. Connor et al. (2000) found certain EF abilities (e.g., verbal fluency measure) to be in line with what would be predicted based on IQ, while others were lower than expected (e.g., WCST). In that these researchers did not match the control group on IQ, this perhaps brings into question some of the conclusions made. Kerns et al. (1997) compared findings from their sample of adults with FASD to a comparison group with no known neurological deficits from a previous study. These researchers concluded that even in the absence of significant cognitive deficits as determined on the basis of IQ tests, persons with FASD experience greater neuropsychological deficits in the areas of attention, memory and EF, than would be predicted on the basis of IQ alone. These analyses did not separate EF from attention and memory, and for this reason it is difficult to conclude definitively if EF deficits are greater than what would be observed in a sample of individuals with similar IQ scores. Moreover, the fact that the specific tasks used by Kerns et al. (1997) differed from those used with the comparison group further limited the extent to which findings could be interpreted.

Hypothesis 3

Compared with the WISC-IV and individual EF scores, the CAS and specifically the Planning and Attention components of the CAS will be better predictors of adaptive behaviour as assessed by the ABAS-II.

Comparisons Across ABAS-II Parent and Teacher Forms

Before exploring the prediction models of the two criterion variables of interest (i.e., ABAS-II Parent GAC, and ABAS-II Teacher GAC), the relation between the parent and teacher ABAS-II scores was examined. The lack of correlation across parent- and teacher-rated adaptive behaviour domains and the finding that parent- and teacher- rated ABAS-II forms differed significantly across all domain and global adaptive domain composites are interesting, given the overlap and similarities between items and domains across the two forms. Comparisons between teacher and parent data were limited to those children (27 of 38) for whom both forms were returned. Across all domains, teachers, relative to parents, had more positive ratings of participants' levels of adaptive skills. This finding may be explained as a function of child-related factors, environment-related factors, differences between raters themselves, or a combination of these factors. To begin, it might be that the classroom, as compared to the home or community, offers a more structured environment for children with FASD, and for this reason students are observed to engage in more positive behaviours in the school. Alternatively, children may be more comfortable in the home environment, relative to the classroom, and thus reveal less adaptive behaviours. Differences in expectations of raters themselves may also be implicated in explaining differences across ratings. For example, it might be that the teachers rating children with FASD, deal with other children with special needs, and for this reason have lowered expectations of behaviour, whereas parents, perhaps lacking this same reference group, may compare their child's behaviours to non-disabled same-aged peers and provide less favourable ratings of their child's behaviours.

Direct comparisons of parent and teacher ratings of adaptive behaviours in children and adolescents with FASD are not readily available, as most studies have relied on parents or guardians as informants when looking at adaptive functioning in persons with FASD (Streissguth et al., 1996; Thomas et al., 1998; Whaley et al., 2001). In those studies where information from both informants is available, researchers have not necessarily compared scores from parents and teachers directly (Schonfeld et al., 2006). Rasmussen, Horne, and Witol (2006) did compare the BRIEF scores provided by parents and teachers. The BRIEF is a measure of EF, and not adaptive behaviour, thus direct comparisons between findings from that study and this study are not necessarily prudent. It is interesting to note, however, that on a functional measure of EF, teachers relative to parents tended to report more difficulties on the BRIEF measure than did parents of children with FASD.

Predicting ABAS-II Parent and Teacher Forms

Based on the discrepancies in scores between the parent and teacher ABAS-II forms, the finding that different variables were helpful in the prediction of these outcomes variables might have been anticipated. In line with findings from previous studies, the findings in the current study did not support the validity of the WISC in predicting adaptive behaviour for children with FASD. Neither the WISC-IV FSIQ nor the CAS FS was found to significantly predict adaptive behaviour in participants as rated by parents or teachers. One might expect that intelligence should, at least to some extent, be predictive of how an individual performs in everyday life. Adaptive skill and intelligence are described as separate but related constructs (Harrison & Oakland, 2003) that appear to be moderately correlated (Boan & Harrison, 1997). In validity studies conducted in the U.S. standardization of the WISC-IV, the WISC-IV FSIQ correlated .41 with the overall ABAS-II Parent Form GAC score and .58 with the ABAS-II Teacher Form GAC score, with stronger correlations found between intelligence and teacher rated adaptive skills (Wechsler et al., 2004). This can be contrasted with findings from the present study, where correlations were not significant between the WISC-IV FSIQ and either parent or teacher ABAS-II GAC, or between the CAS FS and either parent or teacher ABAS-II GAC scores. Validity evidence involving the relations between the WISC-IV and ABAS-II is not provided for any of the "special groups" who participated in the American or Canadian standardization of the WISC-IV. Given the presumed differences that exist between individuals from the U.S. standardization sample and those within the current group, the lack of relation between IQ and adaptive behaviour in this study is not necessarily inconsistent with findings reported for the validation of the WISC-IV.

It was originally hypothesized that the CAS, as compared to the WISC-IV, would be more strongly correlated with EF measures and for that reason would be more strongly predictive of adaptive skills. Interestingly, both the CAS FS and the WISC-IV FSIQ correlated positively with several of the EF measures. Despite this, the CAS FS, like the

WISC-IV FSIQ, was not predictive of ABAS-II GAC. Thus, it appears that even when IQ tests tap EF abilities, this does not necessarily suggest that IQ will be more strongly predictive of adaptive behaviour.

There was, however, some support for the notion that EF, as compared to more composite intelligence scores, would help in the prediction of adaptive behaviour. For parent-rated adaptive behaviour, but not teacher-rated adaptive behaviour, CAS component scores did explain additional variance beyond that explained by the WISC-IV FSIQ. Of particular relevance here were the two CAS components that appeared to be most salient in the prediction of parent-rated adaptive behaviour. Based on semi-partial correlations it appeared that both the Planning Component and the Attention Component, two areas of the CAS that are most closely associated with EF and which represent highly correlated aspects of intelligence, accounted for unique variance in the parent rated adaptive behaviour. Whereas the semi-partial correlation between the Planning Component and parent rated adaptive behaviour was in the direction (positive) that might be anticipated, this was not the case for the Attention Component, where a negative semi-partial correlation was found. As described earlier, it is likely that high correlation between the Attention and Planning components may have influenced the relation between the Attention Component and ABAS-II Parent Form resulting in a negative semi-partial correlation. It appears that the Attention variable, in suppressing irrelevant variance in the Planning Component, acted to enhance the relation between Planning and ABAS-II Parent GAC and the overall multiple regression (Glass & Hopkins, 1996; Henard, 1998). Although Attention was found to contribute to the prediction of parent-rated adaptive behaviour, zero-order correlations between the Attention Component and the GAC do not suggest that these variables are related. Interestingly, none of the correlations between the Attention Component and the ABAS-II Parent domains were significant, whereas all of the correlations between Planning Component and ABAS-II Parent domains were significant. This finding further suggested that the Planning Component was the CAS component most salient in predicting parent-rated adaptive behaviour.

Unlike the EF component (i.e., Planning) of the CAS, the EF component of the WISC-IV (i.e., Working Memory) was not seen to contribute to the prediction of the ABAS-II Parent GAC. The semi-partial correlation between the Working Memory Index and parent-rated adaptive behaviour was not significant. Relative to the WISC-IV Working Memory Index, the CAS Planning Component and the subtests that contribute to this overall score could be described as involving more complex EF abilities, as compared to those involved in the Digit Span and Letter-Number Sequencing subtests. It is possible that the CAS Planning tasks that concurrently tap multiple EF processes may be more relevant to everyday living and for that reason we find stronger associations between the CAS Planning Component with adaptive behaviour. Taken together, these findings may be suggestive of the types of EF tasks that would be more useful in predicting adaptive behaviour in children and adolescents with FASD. Schonfeld et al. (2006) found that functional measures of EF based on the BRIEF to be predictive of social skills in children with FASD. The current study's findings build upon Schonfeld et al.'s research to suggest that certain direct cognitive measures of EF in children with FASD can also predict children and adolescent's overall level of adaptive functioning.

The finding that the CAS Planning Component which represents one of four components in a model of intelligence, is related to adaptive behaviour while the CAS FS, a more global composite of intelligence, is not, may further support the notion of the fractionation of intelligence as previously argued. It is likely that certain areas of intelligence are more relevant to adaptive functioning than others. In combining these different areas into one dimension as reflected in a full-scale composite, we may, in effect, be masking relations that might otherwise be seen if each component of intelligence was viewed separately.

It is interesting to note that the same variables that were predictive of parent-rated adaptive behaviour were not predictive of teacher-rated adaptive behaviour, and vice versa. That is, whereas the CAS components were found to contribute to a model in the prediction of parent-rated adaptive behaviour, such was not the case for teacher rated adaptive behaviour. Likewise, whereas demographic variables were found to help in the prediction of teacher rated adaptive behaviour, age, gender and ethnicity were not seen to be salient in the prediction of parent rated adaptive behaviour. Given the observed lack of relation between the domains of the ABAS-II parent and teacher forms, the differences with regards to what predicts these outcomes may not be surprising.

A perhaps unexpected outcome in the regression analyses performed in this study was the finding that individual EF scores derived from the D-KEFS and the WMTB-C were not together predictive of parent- or teacher-rated adaptive behaviour. Several explanations may be offered to account for this finding. To begin with this lack of relation may be a function of the types of measures chosen and the nature of such measures as lower-order as opposed to more complex EF tasks. As mentioned earlier, it is possible that higher order EF tasks may be more correlated with adaptive behaviour. The lack of relation may also relate to the reliability of the measures employed. Although normative data on standardization samples are suggestive of generally good reliabilities, the reliabilities of these tasks with a sample with FASD, and specifically with the current sample, have not been reported. Due to the nature of the EF tasks employed, the types of reliability analyses that would be appropriate and given limitations in time and resources, reliability analyses for each EF task were not performed. High internal consistency coefficients for the parent and teacher ABAS-II within the current study suggest excellent reliability of the criterion variables. It is possible however, that low reliabilities in the EF measures employed may have attenuated the observed relations.

CHAPTER VI: LIMITATIONS AND IMPLICATIONS

Limitations

Various issues related to the constructs being assessed, the measures that were employed to assess these constructs, and the sample itself constrain the extent to which findings from this study can be interpreted and generalized. To begin with, one of the primary purposes of this study was to assess the usefulness of the Miyake et al. (2000) model in assessing EF in children and adolescents with FASD. This model identifies three areas of EF - Set Shifting, Working Memory and Inhibition - all of which we attempted to measure in the current study. Insofar as the measures employed failed to adequately capture or isolate the constructs of interest (e.g., Tower Test and inhibition), the conclusions being drawn on the basis of such, may be misinformed. EF tasks are often confounded by non-EF related abilities (Delis et al., 2001a); this construct irrelevant variance can influence test scores and thus the relations between these tasks and others. For example, verbal abilities or nonverbal abilities might influence how well an individual performs on an EF task, despite this not necessarily being the variable of interest. In the current study an effort was made to include both verbal and nonverbal EF tasks under each EF area in order to ascertain the possible influence of verbal or perceptual abilities on performance of EF tasks. In the area of Working Memory, this was likely not achieved. Counting Recall was chosen as a measure on nonverbal working memory, however, in that most children employ a verbal strategy (i.e., rehearsal), in recalling this visually presented information, this task is likely better described as a verbal task. Within the areas of Set Shifting and Inhibition, both a verbal and nonverbal task was administered. Based on discrepancies in scores achieved across both tasks, it appears that the participants within this study performed better on the nonverbal, as opposed to verbal, EF task within each EF area.

An additional limitation related to the EF tasks employed involves the Tower Test as a measure of inhibition. Despite some research that suggests that the Tower Test might be better described as a test of inhibition as opposed to a test of planning (Goel & Grafman, 1995; Miyake et al., 2000), it appears that for this group, the Tower Test may be better characterized as a test of planning. It might be for this reason that relations were not found between the Tower Test and the other test of inhibition. Furthermore, the Tower Test is considered a higher-order EF task, unlike the other EF tasks that represent more circumscribed, lower-order EF tasks, and this may have attenuated the relations between this and other EF scores.

The rationale for employing the Miyake et al. (2000) model in this study was to examine whether children and adolescents with FASD tend to perform better or worse across different areas of EF. The small sample size did not allow for factor analysis, making it more difficult to assess whether the two tasks within each EF target area actually clustered together to represent distinct EF areas, and whether participants performed differently across these areas. Despite this limitation, correlational findings did not strongly suggest that one area was separable from another, nor did mean performance on tasks point to limitations specific to one area over the other.

In order to recruit the number of participants necessary for the study design, a large age range of participants was allowed. Given the potential for different developmental trajectories across the various constructs being assessed, it is possible that combining the scores of participants from different age ranges masked relations that might have been seen if smaller age ranges were explored, or whether different patterns of performance might emerge for children within different age bands. Across tasks explored, age correlated with only two measures, those being the Listening Recall and the Tower Test. This finding may be an accurate indication of the relation between age and other variables included in this study; it may also be a function of the smaller sample size where lower statistical power did not allow us to see relations even though they exist.

A large percentage (68%) of the participants within the current study reported having an Aboriginal background. Although rates of FASD are reportedly higher in certain Aboriginal communities (May, Hymbaugh, Aase, & Samet, 1983), the relative prevalence rates of FASD in Aboriginal versus non-Aboriginal persons in the general population are not available (Sampson et al., 1997). As such, it is difficult to establish whether the ratio of Aboriginal to non-Aboriginal participants with FASD in the current study is reflective of that in the general public, and thus whether the findings in this study can generalize to all children and adolescents with FASD living in similar contexts. This issue appears to be a concern to the extent that the Aboriginal children within this study differed in their cognitive or adaptive abilities from non-Aboriginal children. Based on analyses conducted within the current study, differences were not found on the basis of ethnic/racial background. Again, this finding may be related to sample size and lower statistical power. Alternatively, it may have to do with the fact that many of the Aboriginal participants within the current study were being raised in non-Aboriginal homes, where Aboriginal cultural influences are presumably less salient.

A control group was not employed in the present study. Although some might consider this a weakness in the design, there are several arguments as to why this choice was made. To begin, an exploration of the research hypotheses that guided this study did not make necessary the use of a control group. In that the tools used provided standardized scores, a comparison of the performance of participants within the study could be made with those of children and adolescents without a FASD diagnosis that made up the standardization samples. Although a comparison between the study sample and that of the standardization samples does not necessarily take into account various other factors that might influence test performance, it must be noted that matching techniques and the limitations that often characterize this process can also result in imperfect comparisons across groups, and at times in inappropriate conclusions (Stigler & Miller, 1993).

A further limitation of this study relates to the response rate of the ABAS-II teacher questionnaires. Of the 38 possible teachers, 27 completed the ABAS-II Teacher Form. There are several reasons to account for this response rate. For example, in some instances, parents chose not to share information regarding the study with the school, and for that reason teachers were not provided the ABAS-II forms. In other cases, the teacher was contacted and provided the ABAS-II forms, but chose not to participate in the study for personal reasons, or because of concerns regarding the nature of the information being provided. To the extent that participants for whom ABAS-II teacher forms were returned systematically differed from those for whom forms were not returned, the findings of the ABAS-II teacher data may be biased. However, an analysis that compared participants with and those without teacher ABAS-II data revealed no differences on variables such as age, gender, ethnicity, or on all other variables used as predictors in the ABAS-II prediction models, suggesting that these groups do not appear to systematically differ.

Implications

Policy Implications

In the past, researchers and clinicians have commented on the limitations of determining eligibility for services and funding for persons with FASD on the basis of IQ scores (Kerns et al., 1997; Schonfeld et al., 2001), however this continues to be a common practice across North America. Previous research that points to the incongruence between IQ scores and adaptive functioning for persons with FASD (Streissguth et al., 1996; Thomas et al., 1998) suggests why IQ scores may inaccurately identify those who do or do not need service provision. To explain the apparent discord between IQ and adaptive behaviour, some researchers have commented on the failure of IQ tests at adequately measuring EF abilities (Odishaw & Snart, 2005).

One of the main purposes of conducting this study was to examine whether the use of a more theoretically based IQ test that includes EF in its operationalization of intelligence would allow for more accurate prediction of adaptive behaviour. The findings of this study suggest that even when EF is included in how one defines and measures intelligence, an overall IQ score does not adequately predict how a person with FASD functions in everyday life. In line with the notion that intelligence is multidimensional and should be considered as such was the finding that the CAS Planning Component and the CAS Attention Component, unlike the CAS FS, were predictive of adaptive behaviour. If intelligence is truly fractionated, and if one component of intelligence, as compared to another, has more bearing on a person's functioning in everyday life, then perhaps we need to look specifically at this particular component when determining access to services. Despite the fact that the CAS components did account for 45% of the variance in the ABAS-II Parent GAC, the same was not the case for the ABAS-II Teacher GAC, and there still remained a large percentage of unexplained variance even when certain demographic variables were controlled. It appears that EF scores, like an overall IQ score, are insufficient in explaining overall deficits in adaptive behaviour. Of course, this may have to do with the types of EF measures employed in the current study. It is entirely possible that EF measures that are more complex in nature, or those that concurrently assess multiple EF and non-EF related abilities, would be more related to how a person performs in everyday life. In future research that explores the relations between EF and adaptive behaviour in persons with FASD, a more comprehensive battery of both lower-order and higher- order EF tasks might help to elucidate whether certain EF tasks are better at predicting adaptive behaviour.

Based on the findings here, it could be argued that although the component scores derived from the CAS together offer the best predictors of parent-rated adaptive behaviour in children and adolescents with FASD, this still falls short of explaining the degree of adaptive deficits observed by caretakers. Reliance on observational techniques and/or adaptive and behavioural measures by multiple informants may offer a more accurate means for determining a need for service provision. When comparing the finding of moderate correlations between the WISC-IV FSIQ and the ABAS-II GAC in the standardization sample to the lack of correlation between these measures within the current study, it seems plausible that prenatal alcohol exposure moderates the relation between IQ and adaptive behaviour. For this reason, it is important that policy makers recognize the special circumstance of persons with FASD, and allow for alternative measures to be used when determining eligibility for services for this particular population.

Implications for Intervention

A cognitive profile emerged on both the WISC-IV and the CAS. Given the strong theoretical foundation of the CAS, the findings of strengths and weaknesses on this test, as compared to the WISC-IV, might provide more direction for intervention. The CAS is based on the PASS theory of intelligence that organizes cognition on the basis of three interdependent neurological systems: attention-arousal, processing system, and planning. Based on the findings of this study, mean scores suggest that in a testing situation participants were able to exercise directed concentration, to focus on essential details, and to resist distraction. This is perhaps inconsistent with some other research findings where attentional problems have been cited as function of prenatal alcohol exposure. In that several participants were reportedly on medications to treat ADHD, it is possible that performance on attention dependent tasks were enhanced as a function of medical interventions. In terms of processing incoming information, a significant difference between the Simultaneous Processing and Successive Processing components, with higher scores obtained on the former, suggests that on average children and adolescents with FASD, preferred to process information in a gestalt, or as a visual whole, as opposed to sequentially or in a serial order. Successive processing deficits are associated with reading disabilities (Naglieri & Das, 1997), and somewhat lower scores in this area might be relevant to reading difficulties reported for persons with FASD (Howell et al., 2006). Finally, a low score in the area of Planning may be reflective of breakdowns at various stages of problem solving. Planning abilities are related to strategy generation, execution, monitoring, and self-regulation. Understanding at what level(s) of novel problem-solving errors occur would be helpful in generating more meaningful interventions to target this area of weakness. Based on the current evidence it appears that a focus on nonverbal, visual presentation of information may be the preferred way for many children and adolescents with FASD to process information. Furthermore, capitalizing on strengths in the area of Simultaneous Processing to address weaknesses in the area of Planning may be relevant in developing planning skills in persons with FASD.

Some comparisons of profiles can be made across the CAS and the WISC-IV. For example, on both tests particular weaknesses were observed in the area of EF, and particular strengths were observed in components dealing with nonverbal thinking abilities. Comparisons could be drawn between the CAS Simultaneous Processing Component and the WISC-IV Perceptual Reasoning Index. Both areas are related to nonverbal thinking abilities and represent the highest scores across both tests. Interestingly, differences were not observed between the WISC-IV Perceptual Reasoning and the Verbal Comprehension area. Working memory represents one area of EF, and based on performance on the WISC-IV, it appears that this area poses the greatest amount of difficulties for children and adolescents with FASD. Weaknesses in working memory may be directly related to weaknesses in the area of processing speed. There is some research to suggest that the speed of information processing is directly related to working memory (Fry & Hale, 1996; Kail, 2000) in that examinees with slower rates of processing information are thought to place greater demands on working memory. Developing and employing intervention strategies that might target working memory and/or processing speed, would likely yield positive outcomes for those impacted by FASD. New research in the area of EF indicates the potential utility of explicit instruction in the use of rehearsal strategies for memory for numbers in children with FASD (Loomes, Rasmussen, Pei, Manji, & Andrew, in press).

Implications for Future Research

Based on the findings of the current study, some directions for future investigations emerged. Although clinicians and researchers often discuss the potential utility of interventions targeting cognition and more specifically, EF, for persons with FASD (Kahlberg & Buckley, 2007; Watson & Westby, 2003), little research has been done in the area of cognitive intervention for this population. The current study, in highlighting the cognitive profiles of this group on two comprehensive intelligence tests, offers an important starting point for beginning to develop interventions that might target areas of weakness and capitalize on areas of strength. An exploration of the utility of cognitive interventions based on CAS cognitive profiles may offer some direction for meaningful intervention.

Given the limited sample size and the restrictions in EF measures employed in the current study, a future direction might involve a larger scale study to further investigate the nature of EF in children and adolescents with FASD. A replication of the Miyake et al. (2000) design, where multiple lower order and higher order EF tasks are concurrently employed would begin to answer whether the EF tasks function similarly in a population with FASD as compared to a population without FASD. An exploration of verbal and nonverbal EF tasks within each target area would also further our understanding of the relevance of language and perceptual abilities to EF in persons with FASD. Although age did not correlate strongly with many of the measures employed in the current study, a larger sample of children at each age range would help to elucidate the developmental trajectories of EF and adaptive behaviour in children and adolescents with FASD.

The rationale of the current study was related to that of Schonfeld et al. (2006) who found functional assessments of EF to be predictive of social skills in children and adolescents with FASD. Extending the findings of the present study and that of Schonfeld et al. (2006), it seems relevant to concurrently explore the comparative predictive validity of a wide range of cognitive measures of EF with a more functional assessment of the same (e.g., BRIEF). Findings may help to identify particular tools that may be relevant in identifying persons in need of services. Combining this quantitative data with qualitative reports of family members and teachers may help to explicate the nature of the relation between cognition and adaptive behaviour in children and adolescents with FASD. Beyond this, it is anticipated that our increasingly sophisticated means for understanding brain-based behaviours will continue to contribute to a deeper understanding of cognition, behaviour, and the relations between these constructs in persons impacted by prenatal alcohol exposure.

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Appendix A

FETAL ALCOHOL SPECTRUM DISORDER (FASD) STUDY

A study on Fetal Alcohol Spectrum Disorder (FASD) is being done at the University of Alberta.

Who can participate?

- Children and adolescents with a diagnosis of FASD, FAS, FAE, or ARND.
- Must be between **8 to 16 years of age**.

What is involved?

- Participants will be given cognitive tests to see how they think and reason.

Goals of Study:

- To learn which tests best measure the abilities and limitations of individuals with FASD

- To better understand how these test results are related to success in everyday life.

For more information, contact Janine Odishaw at (780) 439-7759 or at janineodishaw@shaw.ca.

Appendix B

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Department of Educational Psychology
Faculty of Education
6-102 Education North
Edmonton, Alberta, Canada T6G 2G5
www.ualberta.ca
Tel: 780.492.5245
Fax: 780.492.1318

Title of Study: Assessment of Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder (FASD): A Promising Alternative to Traditional IQ Tests

Principal Investigator: Dr. Fern Snart, Faculty of Education, University of Alberta

Co-investigator: Janine Odishaw, M.Ed., Faculty of Education, University of Alberta

Introduction

We invite you and your child to participate in a study about children and adolescents with Fetal Alcohol Spectrum Disorder (FASD).

The following information will help you decide if you and your child want to be part of this study. This information will explain why we are doing the study, and how you may be involved. Mark anything you don't understand, or want explained better. After you have read it, please ask questions about anything that is not clear. Whether or not you take part in this study is for you to decide.

Background / Purpose

You and your child have been asked to participate in this study because your child has a clinical diagnosis related to FASD (i.e., Fetal Alcohol Syndrome, Fetal Alcohol Effects, Alcohol Related Neurodevelopmental Disorder). We will be testing about 60 children and adolescents with FASD between the ages of 8 to 16 years.

Tests of intelligence can help to tell us why certain tasks are difficult for a person. They can also help us to develop ways to work more effectively with people. We are doing this study to see which intelligence tests are better at measuring the special abilities and limitations of people with FASD. We hope that the findings of this study will help to influence government policy about which tests of intelligence should be used when assessing people with FASD.

Procedures

If you choose to participate in this study, we will arrange a convenient time to meet with you and your child. The researcher or a trained research assistant will give the intelligence tests and other cognitive tests to your child. Most testing will take place at the Faculty of Education, Clinical Services, University of Alberta. However, the researchers and parents (guardians) may agree on different places for assessment, such as a health centre or the school.

How your child would be involved

Each child will be given two intelligence tests and other cognitive tests. The total amount of time for giving these tests will take between 3 to 4 hours, usually spread over 1 or 2 sessions. Most children find these tests interesting. As researchers we will do our best to make sure that your child enjoys his or her time. If your child gets bored or frustrated with the tests, we will take breaks or end the session and continue another day.

We don't want your child to have to take the same tests over and over again. So, if he or she has recently taken the tests that we will be giving, then we would like to use their original test scores.
For example, if your child recently took the WISC-IV (Wechsler Intelligence Scale for Children – Fourth Edition) in an assessment or for another research project, we ask parents' (guardians') permission to use those test scores for this study.

How you would be involved

As part of this study, parents or guardians are asked to complete two short questionnaires. Questionnaires may be read to parents by the researcher (in person or over the phone), or parents may choose to complete the questionnaires on their own. The first questionnaire asks about your child's current living circumstances and his or her educational history. It should take approximately 20 minutes to complete. In the second questionnaire, parents are asked to rate things such as how their child gets along with other children in the neighbourhood. This questionnaire should also take approximately 20 minutes to complete.

How your child's teacher may be involved

If parents (guardians) agree to involve teachers at the child's school, we will ask your child's teacher(s) to complete a short questionnaire. This questionnaire is like the questionnaire for parents and guardians, but it asks questions about how your child behaves and performs in school. This questionnaire should take approximately 20 minutes to complete.

Possible Benefits

If a recent WISC-IV score is not available, the WISC-IV will be given to your child. Parents (guardians) will then be offered a brief summary of your child's performance on this particular test. The researchers will not interpret your child's performance on the other administered tests. However, you may request that your child's other test results be released to a registered psychologist for interpretation.

Even though there may be no direct benefits of participating in this study, there may be some indirect benefits. In the long-term, this study may affect how government funding is determined for people with FASD. Decisions about whether children and adults with FASD get government funding and help are often based on how well they do on intelligence tests. Not all IQ tests properly measure relevant areas of cognition. Because of this, IQ scores may not be good at predicting how people will do in their lives. They also may not be good at telling us who needs funding and support. This study may help us understand which IQ tests are most appropriate for people with FASD.

We also hope to find out what types of abilities are strengths or weaknesses for people with FASD. Knowing this would help us to develop better ways of helping children and adults with FASD.

Possible Risks

We do not expect any risks for participants in this study. However, if your child becomes bored, frustrated, or upset when taking the tests, he or she will be given a break. During the break, he or she may go for a short walk with the researcher or have a drink or snack. Your child may also visit you at any time. It may be necessary to do the assessment over two days. If this is the case, testing will be stopped and started again on another day.

Voluntary Participation

If you and your child decide to take part, you can still change your mind and stop participating at any time. Your child may also choose to change his or her mind at any time. There will be no negative effects if you or your child decides to withdraw from the study. If you are uncomfortable answering any questions, you are free to refuse to answer

Confidentiality

All information will be held confidential. The information you provide will be kept for at least five years after the study is done. The information will be kept in a secure area (i.e., locked filing cabinet). Your name or any other identifying information will not be attached to the information you give. Your name and your child's name will also never be used in any presentations or publications of the study results.

The information gathered for this study may be looked at again in the future to help us answer other study questions. If so, the ethics board will first review the study to ensure the information is used ethically.

Reimbursement of Expenses

Parents (guardians) will be reimbursed for parking expenses if they have to pay for parking at the testing site.

Contact Names and Telephone Numbers

If you have any concerns about any aspect of the study, please contact the Health Research Ethics Board (HREB) administration office at (780) 492-0302.

If you consent to participate and to have your child participate, please sign the attached Consent Form A and return it to Janine Odishaw. Please also read Consent Forms B and C. Thank-you very much for considering this request. If you have any questions or would like to participate, please contact Janine Odishaw at (780) 439-7759, janineodishaw@shaw.ca.

Janine Odishaw
Department of Educational Psychology
University of Alberta

Parent/Guardian Consent Form A

Title of Project: **Assessment of Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder (FASD): A Promising Alternative to Traditional IQ Tests**		
Part 1: Researcher Information		
Name of Principal Investigator: Dr. Fern Snart (780) 492-3751		
Name of Co-investigator: Janine Odishaw (780) 439-7759		
Part 2: Consent of Subject		
	Yes	**No**
Do you understand that you and your child have been asked to be in a research study?		
Have you read and received a copy of the attached information sheet?		
Do you understand the benefits and risks involved in taking part in this research study?		
Have you had an opportunity to ask questions and discuss the study?		
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not affect your child's care.		
Has the issue of confidentiality been explained to you? Do you understand who will have access to your child's records/information?		
Part 3: Signatures		
This study was explained to me by: ____________________ Date: ________________		
I agree that myself and my child may take part in this study. YES ☐ NO ☐ Signature of Parent/Guardian: ______________________________ Printed Name: ______________________________		
I agree that the researchers may contact my child's school so that his or her teacher may complete a questionnaire about my child. YES ☐ NO ☐ Signature of Parent/Guardian: ______________________________ Printed Name: ______________________________		
I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate. Signature of Researcher: ______________________________ Printed Name: ______________________________		

Parent/Guardian Consent Form B

Please provide your contact information in order for us to contact you to set up a meeting time.

Home Phone Number: ______________________________

Office or Cellular Phone Number: ______________________

Mailing Address: ____

____

Child's Full Name: ____
Child's Date of Birth: (day, month, year)________________________________

Please provide information about where, and by whom your child was diagnosed with a FASD-related diagnosis (e.g., FAS, FAE, or ARND).

Diagnosis made by: ____

Clinic: ____

I agree that the investigators of this research project can contact the Doctor named above to obtain my child's FASD diagnostic results.

Signature: ____

Printed Name: ____

Date: ____

Please give this signed consent form to Janine Odishaw, if you agree to release your child's FASD diagnostic results to the investigators of this study.

Parent/Guardian Consent Form C

1. Has a psychologist, psychiatrist, neurologist, or researcher ever given your child an intelligence test at your child's school, or at another clinic?
   ❑ Yes ❑ No

2. When was the most recent assessment done? ______________________________

3. What is the name and location of the person(s) who conducted your child's most recent assessment(s)? ____
____

4. Why was your child referred for this assessment? ____________________________
____

*If this assessment happened within the past two years, the investigators of this study would like to access this information. Access to test scores would reduce the amount of testing time for your child in the present study. If you agree to this, please sign below.

I agree that the investigators of this research project can contact the above named clinicians/clinics/ schools and or researchers to gain access to results from my child's previous psycho-educational assessment(s).

Signature: ____

Printed Name: ____

Date: ____

Please give this signed consent form to Janine Odishaw, if you agree to release test scores from this previous assessment to the investigators of this study.

For more information regarding this study or about the completion of this form, please feel free to call Janine Odishaw at (780) 439-7759.

Appendix C

UNIVERSITY OF ALBERTA
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Title of Research Study: Assessment of Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder (FASD): A Promising Alternative to Traditional IQ Tests

*Information under the following headings will be described verbally to potential participants.

What will you have to do?: If you and your parents agree to be in this study, I am going to ask you to do a few activities with me. For example, some of them are like puzzles. Most kids find these activities to be more fun than some schoolwork. You will probably like some of them more than others.

Why take these tests? The reason I'm giving you these activities is to find out how you think and learn and to see which ones you like better than others. I will be giving these same tests to other students as well.

Can you quit?: You don't have to take part in the study, and you can quit if you want. No one will be mad at you if you decide you don't want to do this, or if you decide to stop part way through. If you decide that you want to do this and you start to get tired or frustrated once I start asking you questions, just let me know and we can stop and start a bit later. We can take a break when you feel like you need one.

Your signature: We would like you to sign this form to show that you agree to take part. Your mom or dad (guardian) will be asked to sign another form agreeing for you to take part in the study.

Do you have more questions? If you have any more questions, you can ask me or you can ask your mom or dad (guardian) about anything you don't understand.

I agree to take part in the study.

Signature of research participant: ______________________________
Date: ________________________

Signature of researcher: ______________________________________
Date: ________________________

*For participants who are unable or too young to sign their names, verbal assent will be documented by the researcher.

Appendix D

GENERAL INFORMATION AND HISTORY

* **INSTRUCTIONS:** Please indicate your answer by filling in the blank or placing a check mark beside your answer. Only respond to questions that you feel comfortable answering.

General Information

Name of Person Completing this Form: ______________________________

Date: ____________________________
Parent/Guardian Name(s): __________
____
Address: ________________________
____
____
Phone:
(Work)__________________________
(Home) _________________________

Name of Child:___________________
Sex of Child:____________________
Child's Date of Birth:_____________
Child's School: __________________
Grade:_________________________
Homeroom Teacher:_______________

1. What is your child's ethnic background? (e.g., French, Hispanic, Mixed Heritage, Aboriginal: First Nations, Inuit, or Metis)

____

2. Throughout your child's history, has he or she grown up in a mostly rural or urban setting? (please check one of the following)

❑ Mostly rural ❑ Mostly urban ❑ Equal rural and urban ❑ Don't Know

3. Child currently lives with: (please check one of the following)

❑ Both birth parents, or one birth parent and one step-parent
❑ Single birth parent – mother
❑ Single birth parent – father
❑ Adoptive parent(s)
❑ Grandparent(s)
❑ Foster parents(s) or guardian(s)
❑ Group Home
❑ Other ______________________________

4. What language(s) are spoken in the home? (please check one of the following)

❑ Only English
❑ Mostly English
❑ Mostly a language other than English ____________________

If your child was NOT born to your family, please answer question 5.

5. How long has the child been living with you? __________ years

Child's History

6. Has your child ever had **loss of consciousness** due to a concussion or head trauma?
❑ Yes ❑ No ❑ Don't Know

7. If you answered 'yes' to question 6, please answer this question.
When did your child experience this concussion or head trauma? ________years
What happened to cause it? ______________________________
____

8. Has your child ever been diagnosed with any of the following: (place a check beside)

- ❑ Attention Deficit/Hyperactivity Disorder (ADHD)
- ❑ Oppositional Defiance Disorder or Conduct Disorder (ODD or CD)
- ❑ Anxiety Disorder (e.g., Separation Anxiety Disorder or Other)
- ❑ Tourette's Disorder
- ❑ Attachment Disorder
- ❑ Depression
- ❑ Obsessive Compulsive Disorder (OCD)
- ❑ Schizophrenia
- ❑ Seizure Disorder
- ❑ Traumatic Brain Injury
- ❑ Other ______________________________

9. Is your child currently on medication for a medical or psychiatric condition?

❑ Yes ❑ No

10. If yes, what are the medications he/she is on **and** what is he/she taking them for?

____

____

____

11. Does your child wear glasses or contact lenses? ______________________

____

12. Does your child need glasses but does not wear them? ________________

13. Does your child have hearing difficulties? __________________________

Child's Educational History

14. First, place a check mark beside the subjects that your child is taking in school this year. Then circle the grades that he or she is getting? (Please refer to last year's grades if it is too early in this school year to tell what kind of grades your child is getting).

*** If your child receives letter grades (i.e., A, B, C, D) instead of percentages, please follow these guidelines.**

A = 80-100% (above average)
B = 65-79% (average)
C = 50-64% (below average)
D = 0 - 49% (not yet achieving at grade level)

	School Subject	Approximate Grades in Percentage (Please Circle only one option for each subject)
√	**Example:** **French** →	0 – 49% (50 – 64%) 65 – 79% 80 – 100%
	Social Studies/History	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Language Arts/ English	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Math	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Science	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Physical Education	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Art	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Music	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Drama	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Other:___________	0 – 49% 50 – 64% 65 – 79% 80 – 100%
	Other:___________	0 – 49% 50 – 64% 65 – 79% 80 – 100%

15. Has your child always received the same kind of grades in English, Social Studies, Math and Science that you reported for this year? Or have you noticed that he/she seems to be doing better or worse in certain subjects? Explain. (Example: Sally used to do much better in Language Arts, but in grade 4 she started to get lower grades. But her Social Studies, Math, and Science grades have all stayed the same).

____
____
____
____
____
____

16. Has your child ever repeated a grade? (please check one of the following)

❑ Yes ❑ No

17. If you answered 'yes' to question 16, please answer the following question.

What grade(s) did your child repeat? ____________ , ______________

18. Was your child in an early intervention program? (e.g., Head Start Program)

❑ Yes ❑ No

19. Has your child ever been in a special education classroom? (please check one of the following)

❑ Yes ❑ No

20. If you answered 'yes' to question 19, please answer the following.
Please check off the grades when your child was in a special education classroom.

❑ Grade 1
❑ Grade 2
❑ Grade 3
❑ Grade 4
❑ Grade 5
❑ Grade 6
❑ Grade 7
❑ Grade 8
❑ Grade 9
❑ Grade 10
❑ Grade 11
❑ Don't Know

21. If your child is NOT in a special education classroom but gets extra help, what kind of help does he or she get? (e.g., Individual Program Plan (IPP), Teacher Assistant)

____
____
____

22. What does your child get extra help for at school?
(please check at least one of the following)

❑ Nothing
❑ Learning Disability
❑ Physical Disability
❑ Hearing Disability
❑ Visual Disability
❑ Intellectual / Cognitive Disability
❑ Attention Deficit / Hyperactivity Disorder (ADHD)
❑ Communication Delay or Disability (e.g., Expressive Language Disorder, Receptive Language Disorder, Phonological Disorder, Stuttering)
❑ Emotional / Behaviour Disorder
❑ English as a Second Language
❑ Severe Physical or Medical Disability
❑ Other ____________________

23. How many schools has your child attended, beginning with Grade 1? __________

Parent/Guardian Education History and Occupation:

24. What is your highest level of education? (Place check mark beside your answer.)

	Less than Grade 4			Junior college diploma/certificate OR Technical school diploma/certificate
	Less than Grade 9			Bachelor's degree
	High School Graduation			Master's degree
	Completed some college or university courses			Doctoral degree

25. What is your current occupation? ______________________________

26. If your child has another primary caregiver (e.g., father, step-mother), what is his or her highest level of education?

	Less than Grade 4			Junior college diploma/certificate OR Technical school diploma/certificate
	Less than Grade 8			Bachelor's degree
	High School Graduation			Master's degree
	Completed some college or university courses			Doctoral degree

27. What is the occupation of the other caregiver? ______________________

Thank-you for completing this questionnaire!

Appendix E

UNIVERSITY OF ALBERTA
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Tel. 780.492.5245
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Title of Study: Assessment of Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder (FASD): A Promising Alternative to Traditional IQ Tests

Principal Investigator: Dr. Fern Snart, Faculty of Education, University of Alberta

Co-investigator: Janine Odishaw, M.Ed., Faculty of Education, University of Alberta

Introduction

As you are likely aware, a student within one of your classes has a diagnosis related to Fetal Alcohol Spectrum Disorder (i.e., Fetal Alcohol Syndrome, Fetal Alcohol Effects, Alcohol Related Neurodevelopmental Disorder). The parent/guardian of this child has given us permission to contact you about providing further information on this student.

The following information will help you decide if you want to be part of this study. This information will explain why we are doing the study, and how you may be involved. After you have read it, please ask questions about anything that is not clear.

Background / Purpose

We will be testing about 60 children and adolescents with FASD between the ages of 8 to 16 years. The purpose of this study is to see which intelligence tests are best at measuring the abilities and limitations of people with FASD. We hope that the findings of this study will help to determine which tests of intelligence should be used when testing people with FASD.

Tests of intelligence can help to tell us why certain tasks are difficult for a person. They can also help us to develop ways to work more effectively with people. The purpose of this study is to see which intelligence tests are best at measuring the special abilities and limitations of people with FASD. We hope that the findings of this study will promote the use of more effective intervention strategies for persons with FASD. We also hope that the findings will influence government policy about which tests of intelligence should be used when assessing people with FASD.

Procedures

If you agree to participate, you will be asked to complete a brief questionnaire about the skills of a particular student in your class. The questionnaire includes items where you can rank how well a student communicates with others, interacts with other individuals in your class, and performs in academic areas. The questionnaire should take approximately 20 minutes to complete.

Parents or guardians of the student will complete a similar questionnaire about the child's functioning in areas more specific to home life.

Possible Benefits

Decisions about whether children and adults with FASD get government funding and help are often based on how well they do on intelligence tests. Not all IQ tests properly measure all relevant areas of cognitive functioning. Because of this, the IQ scores may not be good at telling us how well people will do in their lives, or who needs funding and support. This study may help us understand which IQ tests are most appropriate for people with FASD. We also hope to find out what types of cognitive abilities are relative strengths or weaknesses for persons with FASD. Knowing this may help us to develop better ways of helping children and adults with FASD.

Possible Risks

We do not anticipate any risks for your participation in this study.

Voluntary Participation

If you decide to take part in this study, you can still change your mind and stop participating at any time. There will no negative effects if you decide to withdraw from the study. If you are uncomfortable answering any questions, you are free to refuse to answer.

Confidentiality

Parents/guardians retain the right to have the information you provide on their child interpreted by a registered psychologist. The information you provide will be kept for at least five years after the study is done. The information will be kept in a secure area (i.e., locked filing cabinet). Your name or any other identifying information will not be attached to the information you give. Your name will also never be used in any presentations or publications of the study results.

The information gathered for this study may be looked at again in the future to help us answer other study questions, If so, the ethics board will first review the study to ensure the information is used ethically.

Contact Numbers

If you have any concerns about any aspect of the study, please contact the Health Research Ethics Board (HREB) administration office at (780) 492-0302. If you consent to participate, please sign the attached Consent Letter and return it to Janine Odishaw.

Thank-you very much for considering this request. If you have any questions or would like to participate, please contact Janine Odishaw at (780) 439-7759, janineodishaw@shaw.ca.

Sincerely,

Janine Odishaw
Department of Educational Psychology, University of Alberta

Teacher Consent Form

Title of Project: **Assessment of Cognitive Processing in Children and Adolescents with Fetal Alcohol Spectrum Disorder (FASD): A Promising Alternative to Traditional IQ Tests**		
Part 1: Researcher Information		
Name of Principal Investigator: Dr. Fern Snart (780) 492-3751		
Name of Co-investigator: Janine Odishaw (780) 439-7759		
Part 2: Consent of Subject		
	Yes	**No**
Do you understand that you have been asked to be in a research study?		
Have you read and received a copy of the attached information sheet?		
Do you understand the benefits and risks involved in taking part in this research study?		
Have you had an opportunity to ask questions and discuss the study?		
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not have implications for you or your student.		
Has the issue of confidentiality been explained to you? Do you understand who will have access to this information?		
Part 3: Signatures		
This study was explained to me by: ______________________ Date: ____________________		
I agree to take part in this study. Signature of Teacher: ____________________________________ Printed Name: ____		
I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate. Signature of Researcher: ____ Printed Name: ____		