University of Alberta

Validity of Simple View of Reading for Predicting Reading Comprehension in Children with Prenatal Alcohol Exposure (PAE) and those with Fetal Alcohol Spectrum Disorders (FASD)

by

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DEDICATION

To my loving husband Paul
Je me tiens sur vos épaules
Je t'aime toujours

To Sundays with Ryshael
my forever friend and
formidable research assistant

To my mother Jeannette
for her love and generous spirit

To my father Jack
who would have been proud

To the children whose families entrusted
their assessment to the FASD Clinic,
may this research be some measure of hope

To Samson
who really wanted to read

The Eagle cried while Samson searched the pages of his book,

looking for Waldo. A smile spread across his face.

Will you read this book, Samson? Read this page, "Sam I am."

The words moved along the page, waters drifting on the lake.

There was no smile to coax and silence spoke: "I really want to read."

The Great Bear that Walks like a Man danced 'round the moon.

And now, Little Boy, why don't you read your books in school?

ABSTRACT

This study examined the validity of Gough and Tunmer's (1986) Simple View of Reading (SVR) model for predicting reading comprehension in children identified as having prenatal alcohol exposure (PAE; n = 36) and those having Fetal Alcohol Spectrum Disorders (FASD; n = 45). In addition to decoding and linguistic comprehension skills, cognitive abilities of verbal learning and short-term memory, inhibition, and working memory were examined for potential contribution of unique variance to reading comprehension. A retrospective case review study involving 81 school-aged children referred to the Glenrose Rehabilitation Hospital Fetal Alcohol Spectrum Disorder Clinical Services was conducted and ANOVAs and hierarchical multiple regression employed. Results showed a significant difference on group performance with variables of decoding, linguistic comprehension, and reading comprehension in favour of the PAE group. The SVR product version was a stronger model for the PAE group, explaining 68% of variance in reading comprehension versus 21% of variance in the FASD group. Regression analysis demonstrated an interaction effect of diagnosis with additional variance of 3.3%. For the FASD group only, verbal memory added 10.3% unique variance (.05 effect size) and inhibition added 7.4% unique variance (.03 effect size). Examination of the deficit pattern of poor readers indicated that the majority had weak skills in both word reading and linguistic comprehension. In both the PAE and FASD subgroups of poor readers, three-quarters of the children showed weakness in word recognition. Nearly two-thirds of children in the FASD sample and nearly one-half of children in the PAE sample showed weakness in linguistic comprehension. In the FASD group, a small number of children were very poor readers despite their adequate performance in decoding and linguistic comprehension. Results of this study have implications for reading interventions and further investigation of cognitive weaknesses that likely impact reading development in children with prenatal exposure to alcohol.

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CHAPTER I

Introduction

Prenatal alcohol exposure (PAE) has been related to poorer academic achievement and an increased chance that a child attends special programs and classes at school (Carmichael Olson, Sampson, Barr, Streissguth, & Bookstein, 1992; Carmichael Olson et al., 1997; Sampson, Streissguth, Barr, & Bookstein, 1989; Streissguth, Barr, Bookstein, Sampson, & Carmichael Olson, 1999). Although delays in reading achievement are reported in the literature in this special population (Coles et al., 1991; Goldschmidt, Richardson, Cornelius, & Day, 2004; Streissguth, Barr, & Sampson, 1990), little research has examined developmental patterns in precursor and reading-related skills that support the development of reading comprehension skills in children identified as having PAE. The main goal of this study is to evaluate the pattern of reading disability in children with PAE and to examine the relationship between reading comprehension and linguistic and cognitive development in this referred group.

Definition and Prevalence of Fetal Alcohol Spectrum Disorder

The distinctive appearance of children born to alcoholic mothers was reported four decades ago by French researchers (Lemoine, Harouseau, Borteryu, & Menuet, 1968) and by American researchers (Jones & Smith, 1973; Jones, Smith, Ulleland, & Streissguth, 1973). Alcohol is a teratogen over the course of prenatal human development and the fetal brain is most sensitive to the damage alcohol induces. The neurotoxic effect of alcohol on the normal architecture of the brain depends on the amount and pattern of maternal drinking, the time of exposure in gestation, and variable maternal and fetal factors (Lockhart, 2001). Symptoms of fetal alcohol syndrome (FAS) such as growth restriction, birth defects, intellectual disability, and dysmorphic facial features at the severe end of the spectrum may be obvious, easily diagnosed, and extremely debilitating; at the mild end of the spectrum, the neurobehavioural deficits of fetal alcohol effects (FAE) may be more subtle but continue to have lifelong implications for learning and development. Both FAS and FAE are included within the diagnosis of fetal alcohol spectrum disorders (FASD).

FASD is an umbrella term referring to the wide range of physical, mental, and behavioural effects and learning disabilities that may occur when an individual is exposed to ethanol during gestation. The diagnosis of an FASD requires a multidisciplinary approach, which encompasses a comprehensive history and physical and neurobehavioural assessments. The Canadian guidelines for diagnosis (Chudley et al., 2005) describe fetal alcohol syndrome (FAS), partial FAS (p-FAS), and alcohol-related neurodevelopmental disorder (ARND) under the umbrella term of FASD. In Canada, the incidence of FASDs is estimated to be 1 in 100 live births (Stade et al., 2009). In the United States, the estimated rates of 0.5–2 for FAS and 10 for FASDs per 1,000 live births (May & Gossage, 2001) are now regarded as conservative estimates by May and colleagues (2006). Based on their epidemiological study in Italy, May and colleagues suggested the overall rate of FASDs may be as high as 2% to 4% in both the U.S. and Western Europe. Sampson, Streissguth, Bookstein, and Barr (2000) estimate the worldwide prevalence of FAS as one to three infants per 1,000 live births. The rate of fetal alcohol effects is estimated as three to four times more prevalent than fetal alcohol syndrome in the general population (Streissguth, 1997). In chapters one and two of my study, PAE (Prenatal Alcohol Exposure) will be used as a collective term to reference children with the potential for brain injury due to exposure to alcohol during the prenatal period.

Model of Reading Comprehension

Simple View of Reading Model

To guide understanding of the learning profiles of children with PAE, Carmichael Olson, Morse, and Huffine (1998) recommend the use of multiple templates based on similarities and differences with other developmental disabilities showing neurological compromise such as dyslexia, attention deficit disorder, autism, or traumatic brain injury. In my study, the prediction of reading achievement is based on the “Simple View of Reading” (SVR) model (Gough & Tunmer, 1986) initially designed to portray the relationship between the two essential elements of reading which have to be developed for successful reading comprehension and if the relationship can be adequately expressed as a multiplicative one. According to Gough and Tunmer, reading comprehension (RC) is the product of decoding (D) and linguistic comprehension (LC); thus, RC = D x C. Decoding refers to the ability to read words and linguistic comprehension refers to the ability to interpret sentences and discourses presented orally. The word recognition component translates print into language, and the comprehension component makes sense of the linguistic information. The SVR model has been used to categorize poor readers into groups on the basis of strengths and weaknesses in word recognition and linguistic comprehension (Aaron, Joshi, & Williams, 1999; Catts, Hogan, & Fey, 2003; Catts & Kamhi, 1999). This classification includes children with deficits in decoding but with normal linguistic comprehension (specific word reading deficit or dyslexia), children with problems in linguistic comprehension but not decoding (specific comprehension deficit), and children with problems in both decoding and linguistic comprehension (mixed deficit).

There is research to indicate that the two main components of SVR (decoding and linguistic comprehension) do not account for all of the reliable variance in reading comprehension and the model should include other cognitive components; for example, fluency (Adlof, Catts, & Little, 2006); naming speed (Johnston & Kirby, 2006; Joshi & Aaron, 2000); vocabulary (Braze, Tabor, Shankweiler, & Menci, 2007; Verhoeven & Van Leeuwe, 2008); performance IQ (Tiu, Thompson, & Lewis, 2003); verbal IQ (Savage, 2006); attentional control (Conners, 2009); and working memory (De Jong & van der Leij, 2002; Georgiou, Das, & Hayward, 2009; Oakhill, Cain & Yuill, 1998). For purposes of this research, measures of verbal learning and memory, inhibition, and working memory will be examined for contribution of additional unique variance in reading comprehension of children with PAE.

Rationale of the Proposed Study

Children with PAE present complex profiles in domains of attention, memory and executive functions (EF) and an extensive literature exists examining the spectrum of cognitive deficits (e.g., Kaemingk & Paquette, 1999; Korkman & Autti-Rämö, 2003; Mattson & Riley, 1998; Mattson, Riley, Gramling, Delis, & Jones, 1998). Research evidence indicates that distinctions such as the absence of dysmorphic features or higher IQ in some individuals do not discriminate the underlying cognitive disturbances that appear related to the FASD disorders phenotype. A review by Kodituwakku (2007) concludes that a “generalized deficit in processing complex information” is the core cognitive-behavioural characteristic of children with PAE (p. 199). In functional neuroimaging studies of individuals with FASDs, the most consistent results show impairment of the frontal cortex, specifically the prefrontal cortex and medial frontal lobe, which are related to EF, working memory (WM), response inhibition, and attention (Malisza, 2007).

To my knowledge, studies have not been conducted on a large sample of children with PAE to examine their pattern of reading comprehension development. When a child with PAE demonstrates reading delay or disability, cognitive factors most likely impinge upon the successful outcomes of reading remediation. The intent of this study is to provide important new information that will help us to understand the nature of reading difficulties and the educational risk factors accompanying children with PAE. Identifying cognitive and linguistic predictors of reading comprehension will aid educators in designing interventions that better target skills needed for reading development.

Linguistic comprehension skills and word reading abilities have identifiable precursors (Storch & Whitehurst, 2002), and intervention can be initiated before children begin formal reading instruction. Identifying the cognitive and linguistic components that best predict reading difficulties within this referred clinical group has the potential to inform reading instruction, educational assistance and social support. In contrast, identifying reading achievement as an area of relative strength for children with PAE could promote educational practices of using reading skills to scaffold weaker areas of learning and social development.

Goals of the Proposed Study

The main goals of this study are: 1) to examine the relationship between reading comprehension and cognitive and linguistic development in school-aged children with prenatal alcohol exposure; and 2) to evaluate the pattern of reading deficits in school-aged children with prenatal alcohol exposure based on the SVR model. A retrospective chart review will allow me to examine factors that are related to reading comprehension outcomes in the sample of children prenatally exposed to alcohol. Using records from the Glenrose Rehabilitation Hospital FASD Clinic, I will focus on school-aged children (8 to 17 years old) identified as having PAE or a diagnosis of an FASD based on the Fetal Alcohol Syndrome Diagnostic and Prevention Network (FAS DPN) four-digit diagnostic code described by Astley and Clarren (2000) and Astley (2004). A control group of children without prenatal alcohol exposure is not used because I am conducting within-subjects analyses comparing correlates of reading comprehension within a referred group of children. Also, it would be difficult to find an appropriate control group because children identified as having prenatal alcohol exposure tend to have other negative life factors (e.g., early environmental risk factors, foster placements, minority group status, etc.) that are difficult to match (Stigler & Miller, 1993) and subsequently it is difficult to make meaningful generalizations to other groups.

CHAPTER II

Literature Review

This literature review is divided into four parts. First, I describe the SVR model used to frame this research study and supporting empirical evidence. Second, I summarize the available reading research for children with PAE and describe the pattern of broad linguistic strengths and weaknesses characteristic of these children. Third, as the additional predictors of reading comprehension in this study, I briefly review research supporting verbal learning and memory, inhibition, and working memory as components of reading comprehension, and describe such abilities in children with PAE. Finally, the questions and hypotheses giving impetus to this research proposal are stated.

Simple View of Reading

Gough and Tunmer (1986) put forth Simple View of Reading as a model for understanding the relationship between two relatively independent skills required for reading comprehension, word reading abilities and linguistic comprehension. In this view, reading comprehension (RC) is the product of decoding (D) and linguistic comprehension (LC); thus, RC = D x LC. Both of these skills are necessary but neither is sufficient for reading (Hoover & Gough, 1990). A child with satisfactory oral language abilities in the absence of adequate decoding skills is not able to gain meaning from print. Conversely, a child with adequate decoding skills but weak linguistic comprehension skills will have difficulty understanding written text. Empirical evidence suggests the SVR model provides a “good fit” based on studies of typical and atypical reading development in students across the school-age range (Florit & Cain, 2011; Kirby & Savage, 2008; Savage, 2006; Stuart, Stainthorp, & Snowling, 2008). One source of evidence is shown in the double dissociation between children who have good decoding skills but poor reading comprehension skills (e.g., Catts, Adlof, & Weismer, 2006; Healy, 1982; Nation, Clarke, Marshall, & Durand, 2004; Nation, Clarke, & Snowling, 2002; Nation & Snowling, 1998), and those who show the reverse pattern of poor decoding and good comprehension (e.g., Byrne & Fielding-Barnsley, 1995; Catts et al., 2003; Hulme & Snowling, 1992; Shankweiler et al., 1999). As well, children may perform poorly on both decoding and comprehension (e.g., Catts, Hogan, & Adlof, 2005). Measures of D and LC have accounted for 48% to 85% of the variance in reading comprehension scores (e.g., Aaron, Joshi, & Williams, 1999; Catts et al., 2005; Hoover & Gough, 1990; Savage, 2006). Individual differences in both D and LC are strongly correlated with variability across children in reading comprehension (e.g., Carver, 1997; Hoover & Gough, 1990; Stanovich, 1986; Vellutino, Tunmer, Jaccard, & Chen, 2007) and across the developmental span (Savage, 2006; Savage & Wolforth, 2007). In elementary grades, longitudinal evidence supports the SVR model as a good predictor of future performance in reading comprehension (Catts et al., 2003; Johnston & Kirby, 2006; Oakhill, Cain, & Bryant, 2003; Tunmer & Hoover, 1992). Finally, there is emerging evidence of genetic influences on individual differences in word recognition and listening comprehension which together accounted for all the genetic influence on reading comprehension in a small sample of twins (Keenan, Betjemann, Wadsworth, DeFries, & Olson, 2006).

The SVR model has been utilized to predict reading development in children with developmental disabilities such as Williams Syndrome (Laing, 2002). Individuals with Williams Syndrome (WS), a neurodevelopmental disorder, typically show a pattern of relative strengths and weaknesses in broad linguistic abilities. Relative strengths in areas related to single-word reading include phonological processing and concrete vocabulary; considerable weakness in areas related to reading comprehension include semantics, relational concepts, receptive grammar, verbal working memory, comprehension monitoring, and discourse skills (Laing, 2002; Mervis, 2009). Research studies consistently have shown that children with WS performed significantly better on single-word reading than on reading comprehension (see Laing, 2002, for a review; Levy, Smith, & Tager-Flusberg, 2003; Menghini, Verucci, & Vicari, 2004).

One question concerns how decoding and linguistic comprehension are best combined to predict reading. In their study of bilingual children, Hoover and Gough (1990) determined that the product version (R = D x LC) rather than the additive version (R = D + LC) accounted for the greater amount of variance in reading comprehension. Chen and Vellutino (1997) showed that incorporating both the sum and the product of decoding and linguistic comprehension, R = D + LC + (D x LC), best fit the data for average readers between Grades 2 and 6. An additive version (D + LC) accounted for more variance than the product or combination versions in a study of teenagers with severe reading delays (Savage, 2006) and in an unselected sample of eight-year-olds (Conners, 2009). Differences in results of these studies may be attributable to sample composition and/or to the measures of decoding and linguistic comprehension utilized. In their study of Grade 3 children, Joshi and Aaron (2000) found that the amount of variance in reading comprehension was similar whether the product (48%) or additive (46%) version was used. They recommended the product version as a better formula because it is applicable to a wide range of reading skills and it makes allowances for non-readers. The three versions will be compared in my study.

Decoding Component

There is remarkable consensus in the learning disabilities literature that a deficit in some aspect of phonological processing, the ability to recognize and manipulate the sound units (phonemes) of oral language, is associated with and predictive of reading failure (Adams, 1990; Liberman, Shankweiler, & Liberman, 1989; Mody, 2003; Wagner & Torgesen, 1987; Wagner, Torgesen, & Rashotte, 1994). In the SVR model, decoding (D) refers to efficient word recognition (Hoover & Gough, 1990) resulting from the application of word identification skills and the rapid retrieval of sight words from one's mental lexicon. Research studies investigating the SVR model vary in their use of measures that tap skills of reading real words (e.g., Gough & Tunmer, 1986; Verhoeven & Van Leeuwe, 2008) or that tap skills of reading nonwords or pseudowords (e.g., Hoover & Gough, 1990; Joshi & Aaron, 2000). The former utilizes phonological knowledge as well as holistic word knowledge, while the latter is dependent upon grapheme-phoneme conversion knowledge.

The predictive abilities of both pseudoword and word recognition measures have been compared with equivocal findings. Chen and Vellutino (1997) found no differences between nonsense-word decoding and word reading as measures of D in their assessment of average readers in grades two to six. Savage (2006) also confirmed that nonsense-word decoding and word reading accuracy were comparable measures of D in his study of teenagers who were poor readers. Johnston and Kirby (2006) tracked students longitudinally from grades three to five and determined that word recognition was the better predictor, presumably as it included more reading-related processes including orthographic processes. In their meta-analysis, Florit and Cain (2011) determined higher correlations between reading comprehension and real word decoding accuracy than between reading comprehension and non-word decoding accuracy. In their findings, word decoding was the best predictor of reading comprehension for school children ages 6 to 11 years. In my study, the measure of D was a word recognition task. It was not possible to examine phonological skills or non-word decoding in the selected sample as such a measure was not administered.

Linguistic Comprehension Component

In the SVR model, linguistic comprehension (LC) is the ability to interpret sentences and discourses presented orally. Storch and Whitehurst (2002) described oral language skills as vocabulary, syntax, discourse, and conceptual knowledges. Roth, Speece, and Cooper (2002) described three domains of oral language related to the development of reading ability: structural language (semantics, morphology, and syntax), metasemantics, and narrative discourse. Semantic knowledge, as measured by word definitions and word retrieval, and metasemantic skill, as measured by comprehension and production of ambiguous sentences, were variables that mediated the oral language–early reading connection. The language problems of poor comprehenders include problems in semantic processing (Nation & Snowling, 1998), morphology and syntax (Hagtvet, 2003; Nation & Snowling, 2000), inferencing (Cain, Oakhill, & Elbro, 2003), figurative language (Nation et al., 2004), and comprehension monitoring (Oakhill & Yuill, 1996). Listening comprehension is another construct that shows a strong relationship with reading comprehension (Catts et al., 2005; Daneman, 1991; Gough & Tunmer, 1986). The numerous subskills believed to comprise listening comprehension include attention, vocabulary knowledge, inferential reasoning, and syntactic and semantic awareness needed to effectively comprehend ideas and information.

Roberts and Scott (2006) provided an expanded illustration of the SVR model for assessment and intervention. In their recommendation, the assessment of oral language would include measures of vocabulary, syntax, morphosyntax, phonology, discourse, and world knowledge. Thus, the complex nature of oral language development may not be captured in single measures of LC often employed in SVR research studies. In addition, the argument put forth by Hoover and Gough (1990) that parallel materials should be used in the assessments of both linguistic and reading comprehension if the SVR model was to be adequately tested, e.g., if narrative material was used in assessing linguistic comprehension then narrative and not expository material must be used in assessing reading comprehension, may not be supported. In my study, the LC measure included skills of vocabulary, structural knowledge of language, and verbal reasoning.

Reading Research in Children with PAE

Decoding Skills

Children with PAE have been reported to show decoding skills below the average in longitudinal studies. Goldschmidt, Richardson, Stoffer, Geva, and Day (1996) reported reduced word reading scores on the Wide Range Achievement Test-Revised (WRAT-R) among six-year-old children who had been exposed to light-to-moderate alcohol use prenatally. At ten years of age, significant effects continued to be found on the WRAT-R word reading subtest (Goldschmidt et al., 2004), although group mean score was within one standard deviation of average (z score = -0.75). Word recognition difficulties often are linked to phonological problems or the ability to incorporate letter-sound correspondence rules (Adams, 1990; Liberman et al., 1989; Wagner & Torgesen, 1987). Streissguth and colleagues (1994) reported scores on pseudoword measures for alcohol-exposed adolescents to be one-third of a standard deviation lower than children of abstainers. In a comprehensive assessment of the neurocognitive status of adolescents with PAE, performance on the NEPSY phonological processing subtest was below average across the total group (at or below -1 standard deviation) and impairment was related to duration of alcohol exposure (Korkman, Kettunen, & Autti- Rämö, 2003). The phonological processing tasks included identification of words from word segments and a test of elision.

In contrast, in a study of adolescents with FAS and borderline to average intellectual abilities, performance on measures of decoding, including nonsense words (Word Attack subtest of Woodcock Reading Mastery Tests) and real words (WRAT-R), was similar to comparison groups and generally consonant with IQ (Carmichael Olson, Feldman, Streissguth, Sampson, & Bookstein, 1998). In a more recent study by Howell, Lynch, Platzmann, Smith, and Coles (2006), alcohol-affected adolescents did not differ significantly from controls on a word reading subtest of the Wechsler Individual Achievement Test (WIAT). Also, a large cohort of adolescents (n=3731) was followed to examine the effects of low-to-moderate levels of alcohol consumption during pregnancy on learning outcomes at 14 years of age (O’Callaghan, O’Callaghan, Najman, Williams, & Bor, 2007). On the word reading subtest of the WRAT-R, mean scores were reported within the average range. Alcohol exposure in late pregnancy was statistically associated with having repeated a grade or requiring remedial help, and with a WRAT-R or Raven’s standard score below one standard deviation.

Linguistic Comprehension Skills

Impairment in the development and use of some aspects of language in children with PAE has been demonstrated (Adnams et al., 2001; Korkman & Autti- Rämö, 2003; McGee, Bjorkquist, Riley, & Mattson, 2009). Research has focused on how well children comprehend and/or produce the structure and content of their language (Abkarian, 1992; Becker, Warr-Leeper, & Leeper, 1990; Carney & Chermak, 1991; Church & Kaltenbach, 1997; Coggins, Timler, & Olswang, 2007; Weinberg, 1997). The results have revealed an array of performance profiles and wide variety of speech and language pathology, such as delays in overall language acquisition, deficits in receptive and expressive language, poor word knowledge, poor comprehension of morphological and syntactic forms, fewer grammatically accurate and complete sentences, and weak nonliteral and inferencing skills. It is commonly reported that children with PAE show discrepancy between their ability to use verbal language and their ability to communicate effectively. Hamilton (1981) described delays in producing syntactically and semantically complex sentences and inappropriate pragmatic responses; however, affected children displayed a superficial conversational talent that often masked weaker linguistic skills. Streissguth, LaDue, and Randels (1986) reported preschool children were excessively talkative and intrusive, and used speech lacking in richness and grammatical complexity. Significant difficulties were reported in the comprehension and use of effective social communication (Coggins, Friet, & Morgan, 1998) and in narrative discourse (Coggins, Olswang, Carmichael Olson, & Timler, 2003). Narratives require speakers to make inferences, link ideas, and take the perspective of others. Taken together, these research studies suggest that children with

PAE are at risk for reading comprehension difficulties due to challenges in their development of structural language, metasemantics, and narrative discourse.

However, in other studies, some school-aged children with PAE are reported to have strong verbal abilities, particularly in the expressive language domain. For example, language form (including syntax, morphology and phonology) as well as language content (such as word and world knowledge) were reported to be within the normal range of performance on standardized assessments (Abkarian, 1992; Clarren et al., 1994; Coggins et al., 2007). Even when children performed within the normal range on standardized language measures, they did not necessarily use the presumed linguistic competence in the service of logical judgment, critical thought, and social problem-solving (Coggins et al., 1998). Such weaknesses likely would impact more integrative tasks of reading comprehension as opposed to word recognition.

Reading Comprehension Skills

To my knowledge, few studies have examined reading comprehension with children exposed to alcohol. In a study by Carmichael Olson, Feldman et al. (1998), adolescents diagnosed with FAS completed a computerized measure of reading comprehension. Participants read a short story, and after every few sentences a set of multiple choice questions was presented. Overall scores were similar to those of the IQ comparison group. In the study by Goldschmidt and colleagues (2004), reading comprehension at age 10 was assessed using the Peabody Individual Achievement Test-Revised (PIAT-R). In this test, the child read one sentence and then selected one of four drawings that best represented the meaning of the sentence. Lower scores in reading comprehension, more than one standard deviation below the mean, were significantly associated with second-trimester binge drinking. In the study by Howell and colleagues (2006), alcohol-affected adolescents did not differ significantly from controls on a word reading test but scored significantly lower on standardized group administered reading achievement tests abstracted from school records. These scores likely would have included a measure of reading comprehension.

In my study, I expect reading comprehension development in this special population to be in accord with linguistic comprehension abilities. Additionally, I expect to find subgroups of readers that reflect decoding-based, comprehension-based, or mixed decoding- and comprehension-based difficulties (Catts et al., 2003; Catts et al., 2006). The utility of categorizing poor readers on the basis of strengths and weaknesses in word recognition and comprehension also has been reported in studies of late-emerging poor readers (Catts, Compton, Tomblin, & Bridges, 2012; Leach, Scarborough, & Rescorla, 2003). Given the significant weaknesses in higher-level reasoning skills and relative strengths in word recognition skills reported in the literature for children with PAE, I expect a larger number of children to meet the category of specific comprehension deficit than the other two categories of specific word reading deficit or mixed deficit. There is a possibility of finding a group of children who exhibit poor reading comprehension despite average performances in D and LC, as described in a study of First Nations children by Georgiou and colleagues (2009). The participants in this study performed below grade level in reading comprehension; however, mean standard score was within the broad range of average. Thus, an argument could be made that these results did not challenge the SVR model. As well, the authors suggested possible limitations due to the use of a pseudoword decoding measure and a single subtest of oral comprehension that utilized a cloze procedure to supply a missing word. As noted by Cutting and Scarborough (2006), the relative contributions of decoding and oral language skills to reading comprehension vary from test to test, and different measures make differential demands on cognitive processes. For example, in comparisons of reading comprehension tests involving a cloze procedure, most of the cloze test variance was accounted for by decoding skill (Francis, Fletcher, Catts, & Tomblin, 2005; Keenan, Betjemann, & Olson, 2008; Nation & Snowling, 1997).

Potential Cognitive Predictors of RC Beyond D and LC

The SVR model asserts that both decoding and linguistic comprehension are necessary for reading success; however, there is uncertainty as to which other cognitive processes may be added to the model to account for additional variance. For purposes of this research, measures of verbal learning and memory, inhibition, and working memory will be examined for potential contribution of additional unique variance in reading comprehension of children with PAE.

Verbal Learning and Memory as Predictors of RC

The implications of verbal learning and memory difficulties for reading comprehension seem apparent. A lack of memory capacity could limit a reader’s ability to organize and retain sufficient information about the words in a text to process meaning adequately (Cain, Oakhill, & Bryant, 2004; Perfetti, Marron, & Foltz, 1996; Swanson & Howell, 2001). The continued change and maturation of memory and information-processing skills are documented throughout childhood, with some variation observed in the developmental trajectories of particular memory functions such as recognition skills, immediate memory capacity, and recall (Anderson, Northam, Hendy, & Wrennall, 2001).

Anderson et al.'s findings showed increased capacity with age to register new information for both verbal and spatial material. The data indicated two developmental "spurts" in immediate memory, the first around age 8 and the second around age 12 (p. 86). The study reported that the ability to recall information after a delay or interference was largely dependent on efficient processing through earlier components of the memory system. Cognitive psychologists suggest that performance increments on memory tests may reflect the use of memory strategies or better capacity to organize information (Bjorklund, 1989; Siegler, 1991). Word list learning tests have the advantage of providing varied clinical data about how memory strategies contribute to free recall and about how the child organizes list items for recall.

In Cutting and Scarborough's (2006) study of school-aged children in grades 1 through 10, the prediction of comprehension scores was not enhanced by any of the verbal memory measures including immediate story retell, nonword repetition, memory for digits, or a sentence span measure. The variance of verbal memory measures reportedly was subsumed within the contributions of word recognition/decoding and oral language proficiency. In a sample of eight-year-old children, Conners (2009) reported that verbal short-term memory (immediate recall), operationalized as word list learning, accounted for significant variance (4 – 5%) in reading comprehension after the effects of decoding and linguistic comprehension, but its contribution was not significant when the effects of attentional control were entered. In a sample of children in grades three to five, Goff, Pratt, and Ong (2005) reported a contribution to reading comprehension of 1% variance, a small effect size, based on the delay trial of the Rey Auditory Verbal Learning Task (RAVLT). None of the immediate memory measures demonstrated independent effects. The authors suggested that the ability to retain and retrieve information after a delay may be a good predictor of reading comprehension. Their stance was in keeping with Cain, Oakhill, Barnes, and Bryant (2001) who found that poor comprehenders had more difficulty retaining new verbal information following a delay, although their short-term retention was similar to those of adequate comprehenders.

Verbal Learning and Memory Deficits in Children with PAE

As previously noted, functional neuroimaging studies of individuals with PAE have shown impairment of the frontal cortex (Malisza, 2007). The frontal lobes aid memory processing by providing organization strategies, and frontal lobe damage interferes with strategic encoding and information retrieval (Di Stefano et al., 2000). In a study by Mattson and Roebuck (2002), school-aged children with PAE displayed deficits in learning and recall of verbal information on the California Verbal Learning Test-Children's Version (CVLT-C) and the Wide Range Assessment of Memory and Learning (WRAML). Compared with controls, the alcohol-exposed children learned less information for all tests and reached a learning plateau earlier. Both groups learned more progressively, suggesting the benefit of repeated exposure to information. The authors hypothesized that variability in the rate of learning by the alcohol-exposed group may be explained by inconsistent attention and/or delayed utilization of learning strategies (e.g., semantic clustering). When corrected for initial amount of information learned, both groups retained the same amount of information over time on the verbal memory measure. In a study by Willoughby, Sheard, Nash, and Rovet (2008) using the Children's Memory Scale (CMS) and the CVLT-C, school-aged children with PAE showed poorer performance than controls in immediate and delayed verbal recall, delayed recognition, and verbal learning tasks. The delayed verbal recall deficits were greater on the CMS than on the CVLT-C tasks, which may be due to the larger number of learning trials on the CVLT-C. These observations of verbal learning and memory deficits in children with PAE suggested that weakness in the encoding process may be at the root of observed memory deficits, as once information was learned it was retained relatively intact (see also, Kaemingk, Mulvaney, & Halverson, 2003; Mattson & Riley, 1998; Mattson et al., 1998; Pei, Rinaldi, Rasmussen, Massey, & Massey, 2008; Willford, Richardson, Leech, & Day, 2004).

Given these challenges in verbal memory, it was expected that verbal learning and delayed recall would account for unique variance in reading comprehension in my study. However, the percent of variance accounted for by verbal memory may be influenced by the particular reading comprehension measure. A measure utilizing a cloze procedure (e.g., Wide Range Achievement Test - Fourth Edition, Wilkinson & Robertson, 2006; Woodcock-Johnson, Third Edition - Tests of Achievement, Woodcock, McGrew, & Mather, 2001) may not demonstrate an effect, in contrast to a reading comprehension measure requiring verbal responses to explicit and implicit questions based on lengthier texts (e.g., Wechsler Individual Achievement Test - Second Edition, The Psychological Corporation, 2003).

Attention as a Predictor of RC

The attention and arousal system is responsible for maintaining an appropriate level of activity in the brain and for ensuring that important stimuli are given the required processing (Baddeley, 1986; Kirby & Williams, 1991; Norman & Shallice, 1986). Numerous research studies (e.g., Rabiner & Coie, 2000; and Torgesen et al., 1999) have demonstrated that attention problems predicted poor reading outcomes in nonalcohol-exposed children. In predicting response to early reading intervention in first-grade students, each of the language-related measures and attention ratings (selective, sustained, and switching) contributed more than verbal IQ for real-word reading and for predicting gains in phonological decoding (Stage, Abbott, Jenkins, & Berninger, 2003).

Detecting and resolving comprehension difficulties involves monitoring automatic reading processes (e.g., decoding accurately; building text meaning), interrupting them when there is a problem, and initiating alternate strategies as necessary (Cain et al., 2004; Conners, 2009). Several studies have operationalized attentional control as the ability to activate and inhibit automatic processes and switch to controlled processes. For example, De Jong and Das-Smaal (1995) found that attentional control accounted for 9% of the variance in reading comprehension in a large sample of fourth graders; Savage, Cornish, Manly, and Hollis (2006) found that response inhibition accounted for 5% of the variance in reading comprehension in a sample of 6 to 11 year-olds rated as low or high in characteristics of Attention Deficit Hyperactivity Disorder; Swanson, Howard, and Saez (2006) found that less-skilled reading groups (i.e., children with reading disability, with comprehension-only deficits, or poor readers) differed significantly from skilled readers on response inhibition tasks. In Conners' (2009) study of 67 eight-year-old school children, depending upon the decoding measure used, attentional control contributed an additional 5 to 10% of variance in reading comprehension when added to the SVR model. Further, attentional control was similar to a measure of linguistic comprehension in accounting for the amount of unique variance.

Attention Deficits in Children with PAE

Findings from the Helsinki longitudinal study demonstrated significant impairment of visual and auditory attention across age levels for alcohol-exposed children (Korkman & Autti- Rämö, 2003). Children with PAE have demonstrated particular difficulties on measures of shifting attention (Coles et al., 1997; Mattson, Calarco, & Lang, 2006; Mattson, Goodman, Caine, Delis, & Riley, 1999; Rasmussen & Bisanz, 2009). In a recent study by Rasmussen and Bisanz (2009), children with FASDs performed significantly lower than the normative mean on a measure of inhibition and inhibition/switching (i.e., the Color-Word Interference test on the Delis Kaplan Executive Function System [D-KEFS]). The low performance was indicative of weakness in verbal inhibition and cognitive flexibility (e.g., conscious control and set-shifting). The authors noted that older children (ages 14–16 years) performed worse relative to the norm than younger children (ages 8–13 years).

In reading, attentional control involves the coordination of automatic and effortful processes (Masson, 1987; Walczyk, 2000). As indicated in reading research literature, weaknesses in attentional control likely impact reading comprehension and warrant investigation as a component of the SVR model (Conners, 2009). In my study, it is expected that complex attentional processes as measured by inhibition tasks would contribute significant variance to reading comprehension.

Working Memory as a Predictor of RC

Working memory is viewed as a flexible mental workspace used to support cognitive activities that require the individual to hold information in mind for a short time while simultaneously carrying out further operations (Baddeley, 1986; Gathercole & Alloway, 2006). For reading comprehension, readers must store recently decoded text while constructing meaning and suppressing irrelevant meaning using complex cognitive processes (Cain et al., 2004; De Beni & Palladino, 2000). As reading progresses, WM stores general information from one or more sentences until a meaning-based representation of the content is formed. The integration of information from one sentence to the next is the essence of comprehension and relies upon an adequately functioning WM (Cain, 2006; Just & Carpenter, 1992).

Numerous studies have reported strong relationships between WM performance and reading skills. In a meta-analysis by Daneman and Merikle (1996), the average correlation between reading comprehension and verbal WM tasks was .41. Complex verbal WM span tasks with both storage and processing components have correlations with reading comprehension typically around .50 (e.g., Daneman & Carpenter, 1980; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000), approaching .70 across a wide range of ages (Swanson & Howell, 2001). In a sample of third- and fourth-grade children, after accounting for decoding skills and vocabulary level, WM tasks (words, sentences, digits) contributed 5 – 10% of variance in reading comprehension (Seigneuric et al., 2000; Seigneuric & Ehrlich, 2005). Results from a three-year longitudinal study on subgroups of school-aged children with reading disabilities showed that less skilled readers had lower levels of WM performance than did skilled readers (Swanson & Jerman, 2007). The authors used a composite measure of WM tasks (backward digit span, updating, digit/sentence span, and rhyming) and they cautioned interpreting individual measures of working memory.

Working Memory Deficits in Children with PAE

Deficits in aspects of WM in children with PAE have been demonstrated (see Rasmussen, 2005, for a review). Performance typically has been poor on phonological (verbal information) measures such as digit span tests (Carmichael Olson et al., 1998; Jacobson et al., 1998) and word/nonword list recall (Rasmussen & Bisanz, 2010). Children with PAE also performed poorly on EF tasks that had a high WM demand (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000; Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995). Measures of WM that have distinguished children with PAE from nonalcohol-exposed controls include the Wechsler Intelligence Scale for Children, Third Edition (WISC-III) Freedom from Distractibility Index Score, comprised of digit span and mental arithmetic (Burden, Jacobson, Sokol, & Jacobson, 2005; Lee, Mattson, & Riley, 2004), and the Children's Memory Scale (CMS) numbers and sequences subtest (Rasmussen, Horne, & Witol, 2006).

Working memory span tasks that require manipulation of linguistic information (e.g., sentences; words) have been more highly correlated with reading comprehension than digit tasks (Cain et al., 2004; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Seigneuric et al., 2000). Since passive, short-term storage of information does not correlate significantly with higher-level WM processes needed for reading comprehension (Carretti, Borella, Cornoldi, & De Beni, 2009; Daneman and Carpenter, 1980), there are challenges in selecting appropriate measures that could expose the process by which reading comprehension may be constrained by WM. In my study, I do not expect the working memory measure to account for unique variance in reading comprehension after controlling for the effects of decoding and linguistic comprehension.

Primary Goal of Study

The primary goal of this study is to identify cognitive and linguistic components that best predict reading difficulties within a referred clinical group. This information has the potential to improve the diagnosis of reading difficulties in children with prenatal exposure to alcohol and to inform reading instruction and educational interventions. The SVR model provides a relatively simple framework to conceptualize reading comprehension and to understand how decoding and linguistic comprehension skills influence reading comprehension development. Determining the validity of the SVR for children identified as having prenatal exposure to alcohol will contribute to the development of evidence-based curricula and interventions important for ameliorating academic problems and the associated incidence of “disrupted school experience” described by Streissguth, Barr, Kogan, and Bookstein (1996). In their survey of 441 clinically referred individuals, 12 years of age and older, 60 – 70% had experienced being suspended, expelled, or had dropped out of school.

Statement of Research Questions and Hypotheses

This study proposes the following research questions and hypotheses:

1. Do school-aged children with an FASD diagnosis demonstrate weaker decoding, linguistic comprehension, and reading comprehension scores than children identified as having PAE? The diagnosis of an FASD indicates the probability of underlying central nervous system (CNS) dysfunction, and I expect linguistic comprehension and reading comprehension skills in the FASD group to be weaker than in the PAE group that is not identified with the same level of neurological

dysfunction. The literature review suggests that decoding skills for both groups should be in the average range.

2. Is the SVR model valid and applicable for children identified as having PAE and those having FASDs and is variance in reading comprehension accounted for similarly in the two groups by different versions of the SVR? I expect the SVR model to be more applicable to children identified as having PAE and less effective in explaining reading comprehension in the FASD group due to the impact of neurological dysfunction. I expect the product version (D x LC = RC) to account for as much or more variance in reading comprehension than the additive or combination versions.
3. Do cognitive abilities of verbal learning and memory, inhibition, and working memory correlate significantly with reading development in children identified as having PAE and those having FASDs? I expect that both verbal memory and inhibition contribute unique variance to reading comprehension (Conners, 2009; Goff et al., 2005), but the measure of working memory, primarily digit span, does not. Working memory tasks that require manipulation of linguistic information (e.g., sentences; words) have been more highly correlated with reading comprehension than digit tasks (Cain et al., 2004; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Seigneuric et al., 2000).
4. What is the number of individuals in poor reader subgroups formed on the basis of weaknesses in word recognition and linguistic comprehension

(Catts et al., 2003)? Given the reports of average word reading skills in children with prenatal alcohol exposure (Goldschmidt et al., 2004; O'Callaghan et al., 2007), I expect that a larger number of children fall into the category of specific comprehension deficit than the other two categories of specific word reading deficit or mixed deficit.

CHAPTER III

Method

Design

The design of this study was quasi-experimental and ANOVAs and hierarchical regression analyses were utilized to examine predictors of reading comprehension. The data presented was originally collected in formal neuropsychological, language, and educational assessments. Using records from the Glenrose Rehabilitation Hospital FASD Clinic (Edmonton, Alberta), a hand-searched retrospective chart review was undertaken on a referred group of school-aged children (8 to 17 years old) prenatally exposed to alcohol. Children were identified as having PAE or an FASD based on the Fetal Alcohol Syndrome Diagnostic and Prevention Network (FAS DPN) four-digit diagnostic code described by Astley and Clarren (2000) and Astley (2004) and used worldwide. The magnitude of expression of four key diagnostic features is ranked independently and assigned a score of 1 to 4, with higher numbers indicating greater pathology. These features are growth deficiency, facial phenotype (short palpebral fissures, flat philtrum, and thin upper lip), CNS dysfunction, and gestational alcohol exposure. Each feature serves as an independent line of evidence and the rankings may or may not converge for a diagnosis of an FASD. In my study, all of the 81 children selected received a ranking of some risk or high risk in confirming gestational alcohol exposure. In the group of children classified as having PAE, one child ranked significant growth deficiency and the remainder with none. In facial phenotype, eight children ranked mild and five moderate. In CNS dysfunction, two children ranked unlikely, 33 possible, and one probable. In the group of children classified as having FASDs, 11 ranked mild growth deficiency, two moderate, and one significant. In facial phenotype, 11 children ranked mild, five moderate, and three severe. In CNS dysfunction, seven children ranked possible and 38 probable. These diagnoses provided two comparison groups (Wass, Mattson, & Riley, 2004) for the purpose of this study.

Selection criteria also included: English as first language; a minimum Full Scale IQ standard score of 70 (Borderline range or above) as measured on the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV, 2003), Wechsler Adult Intelligence Scale (WAIS-III, 1997; WAIS-IV, 2008), or Stanford-Binet Intelligence Scales, Fifth Edition (SB5, 2003); no significant hearing or vision impairments; and no current diagnoses of an autism spectrum disorder or severe psychiatric disorder. Exclusion criterion was grade two children and younger, as studies have indicated that reading comprehension in the early grades was particularly dependent on word recognition skills (Catts et al., 2006; Francis et al., 2005; Parrila, Kirby, & McQuarrie, 2004). Information was collected on measures of intellectual ability, decoding and reading comprehension, linguistic comprehension skills, verbal learning and memory, inhibition, and working memory. Family history and school education were reviewed to determine guardianship, postnatal risk factors, and special education services. All procedures were approved by the Health Research Ethics Board and consent to access FASD Clinic files was provided by Alberta Health Services Management.

Sample

Diagnosing an FASD involved a multidisciplinary team and assessment of factors that were suggestive of brain dysfunction in the absence of “hard” neurological findings of organic brain damage. Unlike a traumatic brain injury that occurs at a specific time and place, the nature of brain damage in an FASD is diffuse rather than specific. The diagnosis of an FASD was made by a qualified team consisting of a developmental pediatrician specifically trained and experienced in FASD diagnosis who performed the neurological and physical assessments and evaluated facial features for dysmorphology; a registered psychologist and a psychometrist who conducted the neuropsychological and educational evaluations; a registered speech-language pathologist who conducted language development assessments; a registered social worker who conducted clinical interviews; and an occupational therapist who evaluated sensory, perceptual, and motor skills (data of which was not referenced in this research). A portion of the measures of intellectual ability and standardized academic achievement was completed by registered psychologists and educational consultants within the community.

Children attending the FASD Clinic were accompanied by birth parents, adoptive parents, foster parents, kinship guardians, or other guardians. Children with prenatal alcohol exposure are at risk of experiencing adverse caregiving environments (Coggins et al., 2007; Hill, Hegemeir, & Tennyson, 1989) that may impact their learning opportunities and development. In this study, specific information on family and educational histories was collected to examine the potential contributions to reading outcomes. This information was limited to a child’s history of postnatal risk factors that were ranked for severity using a defined four-point Likert scale, and to the provision of special education support if known.

To evaluate the Simple View of Reading as a predictor of reading comprehension in this referred group, a total sample of 81 children was selected based on completed measures of decoding, linguistic comprehension, and reading comprehension. Out of the selected children, 36 were identified as having PAE and 45 were identified as having FASDs. The PAE group included 15 (42%) females and 21 (58%) males, ages 8-16 years (M = 11.56; SD = 2.34). Mean Full Scale IQ was standard score 93 (range 79 – 114). The sample was classified into four racial/ethnic categories and included 15 Caucasian, 11 Aboriginal, 5 Métis, and 5 Mixed Race. Guardianship and residency of the children included 13 with biological parent(s), 9 with adoptive parent(s), 6 in foster care, 7 in kinship care, and 1 in group home. Twenty children (56%) attended elementary school (grades 3 - 6) and 16 (44%) attended junior-senior high school (grades 7 - 10). Based on school reports, 64% of the total group received special education services such as an individualized program plan or modified educational program. Additionally in the PAE group, 21 (58%) children were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) of which 52% were on medication for ADHD. Regarding postnatal risk factors, nearly 70% of children were considered to be high risk and 22% at some risk.

The FASD group included 18 (40%) females and 27 (60%) males, ages 8 - 17 years (M = 11.73; SD = 2.91). Mean Full Scale IQ standard score was 83 (range 70 – 108). The sample was classified into four racial/ethnic categories and included 9 Caucasian, 26 Aboriginal, 7 Métis, and 3 Mixed Race. Guardianship and residency of the children included 13 with biological parent(s), 11 with adoptive parent(s), 11 in foster care, 8 in kinship care, and 2 in group home. Twenty-two children with an FASD (49%) attended elementary school (grades 3 - 6) and 23 (51%) attended junior-senior high school (grades 7 - 12). Based on school reports, 80% of the total group received special education services such as an individualized program plan or modified educational program. Additionally in the FASD group, 34 (76%) children were diagnosed with

Attention Deficit Hyperactivity Disorder (ADHD) of which 62% were on medication for ADHD. Regarding postnatal risk factors, nearly 47% of children were considered to be high risk and 40% at some risk.

Measures

Decoding and Reading Comprehension

Wechsler Individual Achievement Test, Second Edition: Canadian (WIAT-II; The Psychological Corporation, 2003) is an individually administered test for assessing the achievement of school-aged children and includes Word Reading and Reading Comprehension subtests. Canadian grade-based norms are used. Scores have a mean of 100 with a standard deviation of 15. According to the manual, test–retest reliability coefficients by age range from .83 to .99. Corrected correlations between WIAT-II Word Reading and Reading Comprehension and WRAT-4 Word Reading and Sentence Comprehension are .71 and .61, respectively (Wilkinson & Robertson, 2006, p. 89). WIAT-II Reading Comprehension and WRAT-4 Reading Composite are correlated at .79.

- Word Reading (child names letters, generates rhyming words, identifies letter sounds, and reads individual words to assess sight word and phonological development).
- Reading Comprehension (child matches word to picture, reads words, sentences, paragraphs, and answers questions that require recalling details, stating main ideas, making inferences, and drawing conclusions).

Wide Range Achievement Test, Fourth Edition (WRAT-4; Wilkinson & Robertson, 2006) is designed to measure basic academic skills and includes Word

Reading and Sentence Comprehension subtests. United States (U.S.) grade-based norms are used. Scores are expressed as standard scores with a mean of 100 and a standard deviation of 15. According to the manual, the average reliability coefficient for all grades is .88. Corrected correlations between WIAT-II Word Reading and Reading Comprehension and WRAT-4 Word Reading and Sentence Comprehension are .71 and .61, respectively (Wilkinson & Robertson, p. 89). Corrected correlations between WJ-III ACH Basic Reading and Passage Comprehension and WRAT-4 Word Reading and Sentence Comprehension are .66 and .60, respectively (Wilkinson & Robertson, p. 90). WJ-III Passage Comprehension and WRAT-4 Reading Composite are correlated at .83.

- Word Reading measures letter and word decoding through letter identification and word recognition.
- Sentence Comprehension measures the ability to gain meaning from words, and to comprehend ideas and information contained in the sentences through the use of a modified cloze technique.

Woodcock-Johnson, Third Edition, Tests of Achievement (WJ-III ACH; Woodcock, McGrew, & Mather, 2001) measures academic achievement in school-aged children and includes Letter Word Identification and Passage Comprehension subtests. U.S. grade-based norms are used. Standard scores have a mean of 100 and a standard deviation of 15. According to the manual, test–retest reliability coefficients by age range from .83 to .92 (Letter Word Identification) and .73 to .89 (Passage Comprehension). Correlations between the WJ-III ACH and WIAT (Wechsler, 1992) on measures of Basic Reading and Reading Comprehension are .82 and .79, respectively.

- The Letter Word Identification subtest requires the individual to identify letters of the alphabet and then read single words.
- The Passage Comprehension subtest uses a cloze procedure that requires the individual to read sentences missing a word that is important to the meaning of the sentence or passage. The individual must give the word that fits the meaning of each sentence or passage.

Linguistic Comprehension

Oral and Written Language Scales: Listening Comprehension Scale (OWLS; Carrow-Woolfolk, 1995). The Listening Comprehension Scale (LC) is designed to assess an individual's ability to understand connected language. It addresses lexical (vocabulary), syntactic (grammar), pragmatic (functional), and supralinguistic (higher-order thinking) structures of language in children and young adults, ages 3 to 21 years. The individual is required to point to one of four pictures presented that matches information read by the examiner. In comparison to vocabulary tests, the LC Scale taps a broader knowledge and flexible use of language, and requires greater attention because the examiner is not allowed to repeat an item. According to the manual, test–retest reliability coefficients for age samples on the LC range from .73 to .80 (Carrow-Woolfolk, 1995).

Clinical Evaluation of Language Fundamentals, Fourth Edition: Understanding Spoken Paragraphs (CELF-4; Semel, Wiig, & Secord, 2003). The Understanding Spoken Paragraphs (USP) subtest is selected in the absence of the Listening Comprehension Scale. The USP subtest evaluates the individual's ability to sustain attention and focus while listening to spoken paragraphs of increasing length/complexity, and to apply critical thinking for text comprehension. The questions target main idea, details, sequencing, inferencing, and predicting. According to the manual, the test–retest reliability coefficients by age are in the .80 range (Semel et al., 2003).

Intellectual Functioning

Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 2003) is used to assess the intellectual ability of children from 6 to 16 years of age. Canadian norms are used. Full Scale and the four-factor index scales each have a mean of 100 with standard deviation of 15, and subtests each have a mean of 10 with standard deviation of 3. Standard scores from 120 to 129 are considered to be in the Superior Range, scores from 110 to 119 in the High Average Range, scores from 90 to 109 in the Average Range, scores from 80 to 89 in the Low Average Range, and scores from 70 to 79 in the Borderline Range. According to the manual, WISC-IV test–retest reliability coefficients based on overall average are .96 for Full Scale IQ score; .93 for Verbal Comprehension index score comprised of Similarities, Vocabulary and Comprehension; .90 for Perceptual Reasoning index score comprised of Block Design, Matrix Reasoning, and Picture Concepts; .91 for Working Memory index score comprised of Digit Span and Letter Number Sequencing; and .90 for Processing Speed index score comprised of Coding and Symbol Search.

Wechsler Adult Intelligence Scale, Third Edition (WAIS-III; Wechsler, 1997) is used to assess the intellectual ability of individuals from 16 to 90 years of age. Canadian norms are used. The WAIS-III measures IQ scores for Verbal, Performance, and Full Scale, and includes a four-factor index model. IQ scores and index scales have a mean of 100 with a standard deviation of 15, and subtests have a mean of 10 with a standard deviation of 3. Standard scores from 120 to 129 are considered to be in the Superior Range, scores from 110 to 119 in the High Average Range, scores from 90 to 109 in the Average Range, scores from 80 to 89 in the Low Average Range, and scores from 70 to 79 in the Borderline Range. According to the manual, WAIS-III test–retest reliability coefficients for the age group 16-17 years old are .97 for Full Scale IQ score; .95 for Verbal Comprehension index score comprised of Similarities, Vocabulary and Information; .90 for Perceptual Organization index score comprised of Block Design, Matrix Reasoning, and Picture Completion; .91 for Working Memory index score comprised of Arithmetic, Digit Span, and Letter Number Sequencing; and .86 for Processing Speed index score comprised of Symbol Search and Coding.

Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV; Wechsler, 2008) is used to assess the intellectual ability of individuals from 16 to 90 years of age. Canadian norms are used. Full scale and the four-factor index scales each have a mean of 100 with standard deviation of 15, and subtests each have a mean of 10 with standard deviation of 3. Standard scores from 120 to 129 are considered to be in the Superior Range, scores from 110 to 119 in the High Average Range, scores from 90 to 109 in the Average Range, scores from 80 to 89 in the Low Average Range, and scores from 70 to 79 in the Borderline Range. According to the manual, WAIS-IV test–retest reliability coefficients for the age group 16 - 17 years old are .97 for Full Scale IQ score; .94 for Verbal Comprehension index score comprised of Similarities, Vocabulary, and Information; .95 for Perceptual Reasoning index score comprised of Block Design, Matrix Reasoning, and Picture Completion; .93 for Working Memory index score comprised of Arithmetic, Digit

Span, and Letter Number Sequencing; and .88 for Processing Speed index score comprised of Symbol Search and Coding.

Stanford-Binet Intelligence Scales, Fifth Edition (SB5; Roid, 2003) is used to assess the intellectual ability of individuals from 2 to 85 years of age. It provides comprehensive coverage of five factors of cognitive ability: Fluid Reasoning, Knowledge, Quantitative Processing, Visual-Spatial Processing, and Working Memory. Full Scale IQ (FSIQ), Verbal IQ (VIQ), Nonverbal IQ (NVIQ), and Composite Indices each have a mean of 100 with standard deviation of 15, and subtest scores have a mean of 10 and standard deviation of 3. Standard scores from 120 to 129 are considered to be in the Superior Range, scores from 110 to 119 in the High Average Range, scores from 90 to 109 in the Average Range, scores from 80 to 89 in the Low Average Range, and scores from 70 to 79 in the Borderline Range. According to the manual, FSIQ, NVIQ, and VIQ reliabilities range from .95 to .98 (average internal consistency composite reliability, across all age groups). Reliabilities for the Factor Indexes range from .90 to .92.

Verbal Learning and Memory

Word list learning tests have the advantage of providing varied clinical data about memory strategies contributing to free recall or how the child organizes list items for recall. Performance on the total learning score and short-delay free recall trial from each measure are the variables to be analyzed (Donders, 1999a; 1999b).

California Verbal Learning Test, Children's Version (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994) and *California Verbal Learning Test, Second Edition Adult Version* (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) are designed to assess verbal learning and memory using a multiple-trial list-learning task. The Total Learning Trials 1 through 5 score is expressed as a T score with a mean of 50 and standard deviation of 10. The remaining scores are presented as Z scores. An individual is required to learn a list of 15 “shopping” items (List A) and recall as many items as possible after each of five presentations of the list. A distracter list (List B) is then presented after the fifth presentation of List A, following which the individual recalls words from List A in a free and then cued recall manner (short-delay trials). After a 20-minute delay, the individual again recalls List A in free and cued recall manners (long-delay trials) and then completes a yes/no recognition task. On the CVLT-II reported split-half reliabilities are high for total learning score (.94 - .96) and for short-delay free recall (.80 - .89); on the CVLT-C test–retest reliability coefficients are adequate (.70 - .79) for total learning score and short-delay free recall for the 12 year-old age group; for the 8 year-old age group test–retest reliability coefficients are adequate (.70 - .79) for total learning score and low (.59) for short-delay free recall (Delis et al., 1994; Delis et al., 2000).

Children’s Auditory Verbal Learning Test, Second Edition (CAVLT-2; Talley, 1993) is designed to assess auditory learning and memory across ages 6 to 17 years. Scores are expressed as standard scores with a mean of 100 and standard deviation of 15. Individuals are required to learn a 16-word Learning List (List A) comprised of elementary school vocabulary, and recall as many items as possible after each of five presentations of the list. An interference list (List B) is then presented after the fifth presentation of List A, following which the individual recalls words from List A in a free and then a cued recall manner (short-delay trials). After a 20-minute delay, the individual again recalls List A and then completes a yes/no recognition task. Generalized coefficients range from .56 to .82 for the Learning List scores, and from .62 to .88 for the Summary Scale scores (Talley, 1993).

Inhibition

NEPSY Second Edition Developmental Neuropsychological Assessment (NEPSY-II; Korkman, Kirk, & Kemp, 2007) is used to assess higher-level cognitive functions in children ages 3 to 12 years. The test selected from the Attention and Executive Functioning domain is Inhibition, a measure of complex attention. Inhibition is a timed task designed to assess the ability to inhibit automatic responses in favour of novel responses, and the ability to switch between response types. There are three conditions: naming, inhibition, and inhibition/switching. The child looks at a series of black-and-white shapes or arrows and names either the shape or direction or an alternate response, depending on the colour of the shape or arrow. Subtest scores are calculated into scaled scores that have a mean of 10 and standard deviation of 3. According to the manual, test–retest reliability coefficients by age are in the moderate to high range. The NEPSY-II Inhibition scores show consistent moderate relationships with the D-KEFS Color Word Interference Inhibition and Inhibition/Switching scores (.27 - .57 correlation), and a moderate relationship (.54 correlation) between the Total Errors scores of the two measures (Korkman et al., 2007b, p. 98).

Delis Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) is used to assess higher-level cognitive functions across ages 8 to 89 years and in this study is used with children 12 years and older. Each task is designed to be a stand alone task that can be administered individually or along with other D-KEFS tests. The Color-Word Interference test is designed to measure verbal inhibition and has four conditions. In all conditions the child is presented with a different sheet of paper with either rows of coloured squares or words on it and is instructed to read across the rows as fast as they can, trying not to make any mistakes. The task includes two baseline conditions: basic naming of color squares (red, blue, green) and basic reading of words that denote colors printed in black ink. On the first interference task, inhibition, the child must say the colour of ink the word is printed in and inhibit reading the word. On the second interference task, inhibition/switching, the child must say the colour of ink the word is printed in and not read the word, *unless* the word is in a box, in which case the child must read the word. The third condition is the traditional Stroop inhibition task and the fourth condition involves both inhibition and switching (cognitive flexibility). Scaled scores with a mean of 10 and standard deviation of 3 are given for completion times for each condition, for contrast measure scores between baseline and higher-level tasks, and for uncorrected and self-corrected error measures. Test–retest reliability coefficients by age range from .79 to .90 (Delis et al., 2001). The Inhibition scaled score is the variable selected.

Working Memory

Wechsler Working Memory Index

The WISC-IV WM Index score (Digit Span and Letter Number Sequencing; Wechsler, 2003) or Wechsler Adult Intelligence Scale WM Index score (Arithmetic, Digit Span, and Letter Number Sequencing; Wechsler, 1997; Wechsler, 2008) will be the variables analyzed. The Wechsler series Digit Span subtest, with immediate repetition either in the forward condition or in reverse order for the backward condition, is considered a test of auditory attention and WM. Different functions may be attributed to digit span forward, a measure of initial registration and efficiency of attention, and digit span backward, a measure of WM (McCloskey & Maerlender, 2005). Younger children may only have the ability to mimic the order of presentation of the stimulus series in Letter Number Sequencing (LNS). For children ages 8 to 16 years, LNS is a more complex working memory task that utilizes additional cognitive processing components of mental manipulation, internal visual scanning, and/or visuospatial processing (Rudel & Denckla, 1974).

Combining Information from Different Measures

All statistical analyses were performed using the statistical software package for the social sciences SPSS 18 or SPSS 19. According to Tabachnick and Fidell (2007, p. 92) transformation of variables at the point of data screening was likely to produce normality, linearity, and homoscedasticity, and usually enhanced the analysis. Therefore descriptive statistics for all measures were collated, and means and standard deviations of performance on the measures reviewed for general trends. Several constructs of interest were measured by different tests and with Canadian or American norms. Notably the U.S. normed WJ-III and WRAT-4 showed higher mean scores than the Canadian normed WIAT-II. This situation created a problem of comparing scores so a procedure was utilized to merge information from different measures into a single measure of each variable (R. Parrila, personal communication, March 2011). This procedure for merging different measures was viewed as conservative in that it likely decreased PAE and FASD group differences because individual scores were adjusted to the combined group mean.

For the PAE group decoding was assessed by WIAT-II (n = 29; M = 88.76; SD = 13.95), by WRAT-4 (n = 4; M = 96.50; SD = 15.35), or by WJ-III (n = 3; M = 102.33;

SD = 20.60); for the FASD group decoding was assessed by WIAT-II (n = 29; M = 82.34; SD = 11.05), by WRAT-4 (n = 9; M = 85.00; SD = 14.66), or by WJ-III (n = 7; M = 81.86; SD = 25.67). For the PAE group reading comprehension was assessed by WIAT-II (n = 29; M = 92.03; SD = 14.66), by WRAT-4 (n = 4; M = 98.25; SD = 21.20), or by WJ-III (n = 3; M = 94.00; SD = 8.89); for the FASD group reading comprehension was assessed by WIAT-II (n = 29; M = 79.76; SD = 8.18), by WRAT-4 (n = 9; M = 84.89; SD = 16.94), or by WJ-III (n = 7; M = 78.86; SD = 10.16). Using WIAT-II as the criterion category, adjustments were made to individual scores on the WJ-III and WRAT-4 calculated in the following manner for each of decoding and reading comprehension scores.

First, PAE and FASD mean group differences between the WIAT-II and WJ-III or WRAT-4, respectively, were calculated and multiplied (weighted) by the number of individuals who received each measure for WJ-III or WRAT-4. Second, the weighted mean differences of the PAE and FASD groups were combined and divided by the total number of individuals for WJ-III or WRAT-4. Third, this calculated mean difference was used to adjust WJ-III or WRAT-4 individual scores on the decoding and reading comprehension measures. WRAT-4 decoding scores were adjusted downward by 4.22 points and WJ-III decoding scores were adjusted by 3.74 points. WRAT-4 reading comprehension scores were adjusted by 5.47 points and WJ-III reading comprehension scores were adjusted by 0.04 points. There was a minimal difference between the WIAT-II and WJ-III reading comprehension means which likely demonstrated the more robust nature of these measures in contrast to the WRAT-4. Finally, single measures of the predictor variable, decoding, and of the dependent variable, reading comprehension, were calculated by combining WIAT-II, adjusted WJ-III and adjusted WRAT-4 standard scores for each of the PAE and FASD groups.

These adjusted scores were mainly in keeping with expectations based on median differences demonstrated in normative studies. For example, the WISC-III Canadian Study (Wechsler, 1996) was initiated when differences larger than could be accounted for by measurement error were found in a representative sample of English-speaking Canadian children. Results showed that Canadian children scored 3.34 FSIQ points above the U.S. WISC-III normative sample. With reference to the WISC-IV (U.S. norms) the mean FSIQ difference between the Canadian and U.S. samples was 2.4 points and the largest difference of 3.0 points was observed on the Verbal Comprehension Index (Wechsler, 2003, pp. 42-43). On the WIAT-II meaningful differences between the U.S. and Canadian samples required the development of Canadian norms (The Psychological Corporation, 2003, pp. 30-32). For example, grade standard scores based on U.S. and Canadian norms showed higher scores obtained using the U.S. norms for Word Reading and Reading Comprehension, respectively, (Grade 3 Canadian sample = 2 points; 4 points; Grade 7 Canadian sample = 8 points; 9 points).

The linguistic comprehension measures were adjusted in the same manner as previously described for the decoding and reading comprehension measures. Using the OWLS as the criterion category, adjustments were made to individual USP standard scores. The PAE linguistic measures included OWLS-LC (n = 32; M = 98.25; SD = 14.40) and USP (n = 4; M = 92.50; SD = 16.58). The FASD linguistic measures included OWLS-LC (n = 39; M = 83.15; SD = 13.35) and USP (n=6; M = 75.83; SD = 14.63). The USP individual scores were adjusted upward by 6.69 points. Finally a single measure of the predictor variable, linguistic comprehension, was calculated by combining OWLS-LC and adjusted USP standard scores for each of the PAE and FASD groups.

The verbal learning and verbal short-term memory measures were adjusted in the same manner as previously described for the decoding and reading comprehension measures. Using the CVLT-C as the criterion category, adjustments were made to individual CAVLT-2 standard scores. The PAE verbal learning measures included CVLT-C (n = 24; M = 108.46; SD = 13.39) and CAVLT-2 (n = 10; M = 108.50; SD = 16.46). The FASD verbal learning measures included CVLT-C (n = 30; M = 95.77; SD = 17.99) and CAVLT-2 (n = 10; M = 91.90; SD = 15.06). The CAVLT-2 verbal learning individual scores were adjusted upward by 1.92 points, and a single measure of the predictor variable, verbal learning, was calculated by combining CVLT-C and adjusted CAVLT-2 standard scores for each of the PAE and FASD groups. The PAE verbal short-term memory measures included CVLT-C (n = 24; M = 105.08; SD = 13.92) and CAVLT-2 (n = 10; M = 108.50; SD = 17.36). The FASD verbal short-term memory measures included CVLT-C (n = 30; M = 92.23; SD = 16.47) and CAVLT-2 (n = 10; M = 101.20; SD = 13.82). The CAVLT-2 verbal short-term memory individual scores were adjusted downward by 6.2 points, and a single measure of the predictor variable, verbal short-term memory, was calculated by combining CVLT-C and adjusted CAVLT-2 standard scores for each of the PAE and FASD groups.

The inhibition measures were adjusted in the same manner as previously described for the decoding and reading comprehension measures. Using the NEPSY-II as the criterion category, adjustments were made to individual DKEFS scores. The PAE inhibition measures included NEPSY-II (n = 22; M = 9.27; SD = 3.51) and DKEFS (n =

10; M = 8.8; SD = 3.74). The FASD inhibition measures included NEPSY-II (n = 33; M = 6.39; SD = 3.23) and DKEFS (n = 8; M = 6.87; SD = 4.02). The calculated adjustment was negligible (0.05 points). Thus a single measure of the predictor variable, inhibition, was calculated by combining NEPSY-II and DKEFS scaled scores for each of the PAE and FASD groups.

CHAPTER IV

Results

Descriptive Statistics

Descriptive statistics for all measures were collated, and means and standard deviations of performance on the measures reviewed for general trends and normalcy based on skewness and kurtosis. These results are presented in Table 4.1 for the PAE and FASD groups.

Assumptions of normalcy appeared violated on the measure of linguistic comprehension for the PAE group and on measures of word reading and linguistic comprehension for the FASD group. Further review of the data by examining box plots and detrended normal Q-Q plots indicated six potential outliers. The PAE group had one linguistic comprehension outlier. The FASD group had two linguistic comprehension outliers, two reading comprehension outliers, and one word reading outlier. Following the guidelines of Tabachnick and Fidell (2007), in a population in which the distribution for a variable has more extreme values than a normal population it was appropriate to retain the outlier(s) but to consider changing the extreme value to reduce its impact. Thus results were analyzed in two ways. In the first analysis no adjustments were made to the data. In the second analysis extreme values were adjusted upward or downward and given the value of one standard score point more or less than the next nearest data point.

The general trend and pattern of results for unadjusted and adjusted data were similar with no significant differences; therefore the original data set was retained for further analyses. Results for the adjusted data are provided in Appendix A.

Table 4.1 Descriptive Statistics of General Trends and Normalcy

Measure	N	Min	Max	Mean	Std. Dev	Skewness Stat	Std. Err	Kurtosis Stat	Std. Err
PAE									
IQ (full scale)	36	79	114	93.22	9.62	.398	.393	-.623	.768
Word Reading	36	56	120	89.97	14.43	-.164	.393	-.296	.768
Reading Comprehension	36	66	125	92.33	14.67	.531	.393	-.164	.768
Linguistic Comprehension	36	74	144	98.39	14.40	.821	.393	1.477	.768
Verbal Learning	34	79	134	109.06	14.13	-.309	.403	-.770	.788
Verbal Memory	34	77	130	104.32	14.79	-.360	.403	-.800	.788
Inhibition	32	1	14	9.12	3.52	-.638	.414	-.558	.809
Working Memory	36	68	117	93.22	12.34	-.298	.393	-.476	.768
FASD									
IQ (full scale)	45	70	108	82.60	8.94	.850	.354	.320	.695
Word Reading	45	31	111	81.37	14.46	-.700	.354	2.144	.695
Reading Comprehension	45	50	107	79.64	10.44	-.097	.354	1.074	.695
Linguistic Comprehension	45	40	106	83.11	13.35	-1.060	.354	1.952	.695
Verbal Learning	40	58	131	95.30	17.13	-.113	.374	-.078	.733
Verbal Memory	40	55	130	92.98	15.73	-.203	.374	.096	.733
Inhibition	41	2	14	6.49	3.37	.708	.369	-.490	.724
Working Memory	39	56	114	82.85	14.01	.497	.378	.132	.741

Question One: Do Group Differences Exist on D, LC, and RC Variables?

Table 4.2 shows the means and standard deviations for decoding, linguistic comprehension, and reading comprehension for PAE and FASD groups. In the PAE group, mean standard scores were in the average range. Decoding was the weakest variable and not a particular strength in contrast to expectations based on the literature review. The least affected variable and a relative strength was linguistic comprehension which is one domain of the diagnostic assessment used to differentiate children with FASDs from children identified as having PAE. In the FASD group, mean standard scores were below average and comparable across variables. Decoding was not within the average range in contrast to expectations based on the literature review. Reading comprehension appeared as the weakest variable, relatively.

To determine if group differences exist on decoding, linguistic comprehension, or reading comprehension, PAE and FASD group means (see Table 4.2) were compared using one-way analysis of variance. These analyses showed significant differences between the PAE and FASD groups on decoding, F (1, 79) = 7.08, p = .01; linguistic comprehension, F (1, 79) = 24.41, p = .001; and reading comprehension, F (1, 79) = 20.63, p = .001. The effect size, calculated using *Cohen's d*, was medium for decoding, and large for linguistic comprehension and reading comprehension (Cohen, 1988, p. 22).

Table 4.2 Descriptive Statistics of SVR Variables, F values and Effect Size

	PAE		FASD			
	M	SD	M	SD	F	Cohen's d
D	89.97	14.43	81.37	14.46	7.079**	0.60
LC	98.39	14.41	83.11	13.35	24.412***	1.10
RC	92.33	14.67	79.64	10.44	20.628***	1.00

Note: D=Decoding; LC=Linguistic Comprehension; RC=Reading Comprehension
DF = 1, 79: **p <.01; ***p <.001

Question Two: Is SVR Model Valid as Predictor of Reading Comprehension?

The second question examined the validity of the SVR model for predicting RC in each of the PAE and FASD groups. The relationship between product, additive and combination versions, respectively, and RC was investigated using Pearson product-moment correlation coefficient, and values interpreted based on Cohen's (1988, pp. 79-81) guidelines. In the PAE group there was a large positive correlation between product or combination versions and RC, $r = .82$, $n = 36$, $p < .001$, as well as between additive version and RC, $r = .81$, $n = 36$, $p < .001$. In the FASD group there was a medium positive correlation between product or combination versions and RC, $r = .45$, $n = 45$, $p < .01$, as well as between additive version and RC, $r = .44$, $n = 45$, $p < .01$. The proportion of variance in RC accounted for by three versions of the SVR is shown in Table 4.3. The results showed that D and LC account for significant amounts of RC variance in each version. In the PAE group, 68% of variance was explained by each of the product or combination version, and 66% by the additive version. For the FASD group, 21% of variance was explained by the product or combination version, and 20% by the additive version. Although the variance explained was significant in both groups, the SVR model clearly explains more of the RC variance for the PAE group than for the FASD group.

Table 4.3 Variance in RC accounted for by three versions of SVR

Model Version	R^2 PAE	R^2 FASD
Product: RC = D x LC	0.68***	0.21**
Additive: RC = D + LC	0.66***	0.20**
Combination: RC = D + LC + (D x LC)	0.68***	0.21**

Note: Dependent Variable: RC; **p <.01, ***p <.001

To further evaluate the potential interaction effect of diagnosis in each version of the SVR model, regression analysis was utilized. R square change values from these analyses are presented in Tables 4.4, 4.5, and 4.6. There was a difference in the amount of unique variance explained by the SVR model for PAE versus FASD groups. This can be supported by the small but significant additional variance explained by the interaction between diagnosis and product predictor (3.3%), additive predictor (4.8%), and combination predictor (3.4%).

Table 4.4 Regression Analyses of Diagnosis as Predictor of RC

		ß	ΔR^2
Step 1	Diagnosis	-0.144	0.016
	Product Predictor (RC=DxLC)	0.675	.359***
Step 2	Diagnosis	0.547	.019
	Product Predictor	0.853	.330***
	Diagnosis X Product Predictor	-0.655	.033*

Note: *p < .05; ***p < .001

Table 4.5 Regression Analyses of Diagnosis as Predictor of RC

		ß	ΔR^2
Step 1	Diagnosis	-0.158	0.020
	Additive Predictor (RC=D+LC)	0.649	.332***
Step 2	Diagnosis	1.515	.039**
	Additive Predictor	0.890	.320***
	Diagnosis X Additive Predictor	-1.591	.048**

Note: *p < .05; **p < .01; ***p < .001

Table 4.6 Regression Analyses of Diagnosis as Predictor of RC

		ß	ΔR^2
Step 1	Diagnosis	-0.144	0.016
	Combination Predictor (RC=D+LC+DxLC)	0.675	.359***
Step 2	Diagnosis	0.557	.020
	Combined Predictor	0.853	.329***
	Diagnosis X Combination Predictor	-0.664	.034*

Note: *p < .05; ***p < .001

All of the above analyses were completed using the largest possible sample that involved the combined measures described in the methods chapter. Further investigation of the robustness of observed differences was undertaken by repeating the analyses comparing group means on decoding, linguistic comprehension, and reading comprehension variables in two ways. First, analyses were repeated utilizing the largest possible sample but with outliers adjusted as earlier described. Means, standard deviations, F values, and effect sizes for group comparisons are shown in Table 4.7. Group differences were examined through comparison of PAE and FASD group means using ANOVA and regression analysis, and results reported in Appendix A.

Second, analyses were repeated using only the subsample of children in the PAE group (n = 29) and FASD group (n = 29) who had completed the WIAT-II decoding and reading comprehension measures. In this subsample the OWLS linguistic comprehension measure also was completed by the majority of the children. The PAE linguistic comprehension variable included OWLS (n=25) and USP (n=4). The FASD linguistic comprehension variable included OWLS (n=24) and USP (n=5). Means, standard deviations, F values, and effect sizes for group comparisons are shown in Table 4.8. Group differences were examined through comparison of PAE and FASD group

Table 4.7 Descriptive Statistics of SVR Variables, F values, and Effect Size with outliers adjusted

	PAE		FASD			
	M	SD	M	SD	F	Cohen's d
D	89.97	14.43	81.92	12.90	7.002**	0.59
LC	97.81	12.85	83.87	11.36	26.799***	1.15
RC	92.33	14.67	79.69	9.45	22.032***	1.02

Note: D=Decoding; LC=Linguistic Comprehension; RC=Reading Comprehension
DF = 1, 79: **p <.01; ***p <.001

Table 4.8 WIAT-II Descriptive SVR Variables, F values, and Effect Size

	PAE		FASD			
	M	SD	M	SD	F	Cohen's d
D	88.76	13.95	82.34	11.05	3.768*	0.51
LC	98.41	15.09	82.83	13.30	17.418***	1.10
RC	92.03	14.66	79.76	8.18	15.508***	1.03

Note: D=Decoding; LC=Linguistic Comprehension; RC=Reading Comprehension
DF = 1, 56: *p = 0.057; ***p < 0.001

means using ANOVA and regression analysis, and results reported in Appendix B.

The general trend and pattern of results was similar throughout analyses utilizing the original research data with or without outliers adjusted, or the subsample with WIAT-II data. The results showed group differences and medium to large effects on the variables of decoding, linguistic comprehension, and reading comprehension in favour of the PAE group versus the FASD group. Similarly the SVR product version was a good fit for explaining much of the variance in RC for both groups and in particular for the PAE group. In the PAE group 70% of variance was explained by the product version utilizing data with outliers adjusted and 68% of variance utilizing the subsample data. In the FASD group 22% of variance was explained by the product version utilizing data with outliers adjusted; the variance was not significant utilizing the subsample data. In this clinical group the smaller sample size showed less variability and more clustering of scores on the RC measure resulting in a restricted range (SD = 8.18) which likely accounted for the insignificant effect. However, Cohen's guidelines for interpreting the effect size *r* independent of the sample size indicated a medium effect size (1988, p. 22). The SVR product version was adopted for further analyses being as good a fit as the combination version and slightly better than the additive version for explaining variance in reading comprehension for both groups. The product version is the original model and recommended as a better formula for expressing the relationship between decoding and linguistic comprehension because it makes allowances for nonreaders (Hoover & Gough, 1990; Joshi & Aaron, 2000).

Question Three: Do Verbal Learning, Verbal Memory, Inhibition, or WM Contribute Unique Variance to Reading Comprehension?

To determine if verbal learning, verbal short-term memory, inhibition, or working memory explained unique variance in reading comprehension, hierarchical regression analysis was utilized. Pairwise exclusion of missing data was used so that cases were included in any of the analyses for which a case had the necessary information. This procedure avoided limiting the sample size to only a subset of cases that had all of the independent variables. Given the significant group differences already described, hierarchical regression analyses were performed separately for the two groups.

Although the SVR model explained a large proportion of variance in reading comprehension in the PAE group, it did not account for the same variance in the FASD group. To examine which additional predictor variables could potentially be important, regression analysis was repeated on each of the PAE and FASD groups separately. Variables were entered in blocks in a predetermined order. In the first block, the product version of SVR was entered. In the second block, the independent variables were entered simultaneously. The results are shown in Table 4.9. For the PAE group, total variance explained by the model as a whole was 73.1%, F (8, 22) = 7.461, $p < .001$. After the variables in Block 1 were entered, the model explained 67.9 % of variance in RC, ΔF (1, 29) = 61.357, $p < .001$. After all remaining independent variables were entered in Block

2, the model explained additional 5.2% of variance in RC, ΔF (7, 22) = .603, p = .747, which did not reach statistical significance. In the PAE group none of the independent variables predicted statistical significant share of reading comprehension variance.

For the FASD group, total variance explained by the model as a whole was 37.1% and approached statistical significance, *F* (8, 29) = 2.139, p < .10. After the variables in Block 1 were entered, the model explained 20.6 % of variance in RC, ΔF (1, 36) = 61.357, p < .01. After all remaining independent variables were entered in Block 2, the model explained additional 16.5% of variance in RC, ΔF (7, 29) = 1.087, p = .397, but did not reach statistical significance. In the FASD group, Verbal Memory contributed 10.3% of unique variance; p = .038. Inhibition contributed 7.4% of unique variance; p = .075. Cohen's (1988) guidelines for interpreting the effect size *r* indicated that Verbal Memory had a large (.5) effect size and Inhibition had a medium (.3) effect size. These values appeared only for the FASD group, suggesting these independent variables may have a different impact on this group of children.

Table 4.9 Regression Analyses Examining Contribution of Independent Variables

Independent Variable	N	ß	Sig.	ΔR^2
PAE				
Full Scale IQ	36	.512	.202	.021
Nonverbal IQ	36	-.224	.308	.013
Verbal IQ	36	-.020	.933	.000
Verbal Learning	34	.031	.845	.000
Verbal Memory	34	-.022	.896	.000
Inhibition	32	-.125	.411	.009
Working Memory	36	-.097	.623	.003

to continue

Table 4.9 continued

Independent Variable	N	ß	Sig.	ΔR^2
<u>FASD</u>				
Full Scale IQ	45	-.143	.810	.001
Nonverbal IQ	45	-.047	.870	.001
Verbal IQ	45	.080	.776	.002
Verbal Learning	40	-.250	.236	.032
Verbal Memory	40	.503	.038	.103
Inhibition	41	.318	.075	.074
Working Memory	43	.163	.650	.005

Question Four: What is the Pattern of Reader Subgroups?

Using the classification proposed by Catts et al. (2003), readers were delineated into four subgroups on the basis of individual performance on the decoding (D) and linguistic comprehension (LC) measures when the individual scored at least one standard deviation (16^{th} percentile) below the mean on reading comprehension. The cut-off value for poor decoding or linguistic comprehension also was at least -1*SD*. According to this scheme, individuals with good or at least adequate linguistic comprehension and poor decoding were classified as having specific word reading deficits. Those with good or at least adequate decoding but poor linguistic comprehension were classified as having specific comprehension deficits. Those with poor performance in both decoding and linguistic comprehension were classified as having mixed deficits. Finally, a nonspecified subgroup was comprised of poor readers with adequate performance in both decoding and linguistic comprehension.

In the PAE group, 13 children scored at or below the 16^{th} percentile in reading comprehension. Of these children, five showed a pattern of word reading deficit; one showed a pattern of specific comprehension deficit; five met criteria for a mixed deficit pattern; and two fell into the unspecified subgroup. Thus, the majority of these children (77%) fell into the subgroups of word reading deficit and mixed deficit and shared a weakness in word recognition abilities. The mixed deficit subgroup combined with the specific comprehension subgroup indicated that nearly half (46%) of the children showed weakness in linguistic comprehension. The two children in the nonspecified poor reader group showed scores above the cut-off level in decoding and linguistic comprehension. Both of the children's reading comprehension scores (14^{th} percentile) were nearly at the level of adequate performance.

In the FASD group, 32 children scored at or below the 16^{th} percentile in reading comprehension. Of these children, eight showed a pattern of word reading deficit; four showed a pattern of specific comprehension deficit; 16 met criteria for a mixed deficit pattern; and four fell into the unspecified subgroup. The majority of these children (50%) showed a mixed deficit of word reading and linguistic comprehension. Combined with the word reading deficit subgroup, 75% of the children shared a weakness in word recognition abilities. Combined with the specific comprehension subgroup, 63% of the children shared a weakness in linguistic comprehension. The four children in the nonspecified poor reader group showed scores above the cut-off level in decoding and linguistic comprehension. One of the children showed linguistic comprehension performance barely at an adequate level (18^{th} percentile). The other three children scored extremely low in reading comprehension even with having average scores in decoding and linguistic comprehension. This subgroup was not predicted by the Simple View of Reading model.

To summarize, the majority of children demonstrated weak skills in both word reading and linguistic comprehension. In both the PAE and FASD samples, three-quarters of the children showed weakness in word recognition. Nearly two-thirds of children in the FASD sample and nearly one-half of children in the PAE sample showed weakness in linguistic comprehension. In the FASD group, a small number of children were very poor readers despite their adequate performance in decoding and linguistic comprehension.

CHAPTER V

Discussion

The main goals of this study were to examine the relationship between reading comprehension and cognitive and linguistic development in school-aged children with prenatal exposure to alcohol and to evaluate their pattern of reading comprehension deficits based on the Simple View of Reading model. This information has the potential to improve the diagnosis of reading difficulties in children with prenatal alcohol exposure and to inform reading instruction and educational interventions. A retrospective case review was conducted and group differences between children identified as having PAE or having FASDs were compared using one-way analysis of variance and hierarchical multiple regression. The findings and implications are discussed in detail below.

Key Findings

My first research question concerned PAE and FASD group differences on variables of decoding, linguistic comprehension, and reading comprehension. In the PAE group, mean standard scores for all variables were in the average range. Decoding was the weakest variable (*z*-score = -0.80) and not a particular strength in contrast to expectations based on the literature review. Reading comprehension was in the average range (*z*-score = -0.50). The least affected variable and a relative strength was linguistic comprehension (*z*-score = -0.20). In the FASD group, mean standard scores were below average and similar across variables. Decoding (*z*-score = -1.30) was not within the average range in contrast to expectations based on the literature review. As expected linguistic comprehension was below average (*z*-score = -1.20) and reflective of weakness in the language domain that is used to assist with establishing a diagnosis of an FASD.

Reading comprehension (*z*-score = -1.40) appeared as the weakest variable, relatively. The few studies of reading comprehension with alcohol-exposed children described in the literature reported below average scores (Goldschmidt et al., 2004; Howell et al., 2006). Further in my study, one-way analysis of variance revealed significant group differences on decoding, linguistic comprehension, and reading comprehension. The effect size *d* was medium for decoding and large for linguistic comprehension and reading comprehension.

These results confirmed my expectation that linguistic comprehension and reading comprehension skills are weaker in the FASD group than in the PAE group due to the probability of underlying central nervous system damage in the FASD group. The finding of below average decoding skills is in contrast with those of Goldschmidt et al. (2004) and O'Callaghan et al. (2007) whose studies reported word reading scores on subtests of the WRAT-R to be in the average range; Howell et al. (2006) reported word reading scores on the WIAT to be comparable to a control group, albeit both groups showed mean scores below one standard deviation of the mean. It is difficult to ascertain the comparability of inclusion and exclusion criteria of those studies reporting average word reading scores. These studies indicated the children were exposed to the effects of low to moderate levels of alcohol consumption prenatally; it is possible that my sample had a larger prenatal exposure to alcohol due to the criteria used for access to the clinic from which my sample was drawn. As well, the very large cohort (n = 3731) in the study by O'Callaghan and colleagues may have influenced scores relative to the number of children prenatally exposed to low versus moderate alcohol consumption. In the studies by Howell and colleagues and O'Callaghan and colleagues, the mean age of the sample was 15 years and 14 years, respectively, in comparison to the mean age of 11 years in my sample. Exposure to several years of additional reading instruction and practice may have influenced the former word reading scores, and particularly if the word reading measure had weak psychometric properties, e.g., limited items within each age range often seen in academic screeners such as the WRAT-R. Also research suggests that older norms produce inflated scores on assessment measures (Flynn, 1984, 1987). Thus, test scores need to be based on normative information that is contemporary and representative of the relevant population. Another consideration for the discrepant findings may be differences in Canadian norms versus U.S. norms in which higher scores have been obtained using U.S. norms (The Psychological Corporation, 2003). In my study, children were selected only if they had completed the most current standardized tests of word reading available, i.e., WIAT-II, WJ-III, and WRAT-4, and the scores were adjusted to reflect the Canadian norms available for WIAT-II, the most commonly used measure.

My second research question addressed the validity of the SVR model for children identified as having PAE and those having FASDs. The SVR product version was as good a fit as the combination version and slightly better than the additive version for explaining much of the variance in reading comprehension for both groups. This finding was in keeping with my expectations and with research by Joshi and Aaron (2000) who recommended the product version as a better formula. The SVR model explained a significant amount of variance (68%) in reading comprehension for children in the PAE group. This finding was in keeping with studies reporting that measures of decoding and linguistic comprehension have accounted for 48% to 85% of variance in reading comprehension scores (e.g., Aaron, Joshi, & Williams, 1999; Catts et al., 2005; Hoover & Gough, 1990; Savage, 2006). Although the SVR model also explained a statistically significant amount of variance (21%) in reading comprehension for children with FASDs, it was clearly a better model for the PAE group. These results were in keeping with my expectations for the SVR model to be most applicable to children identified as having PAE and less effective in explaining reading comprehension in the FASD group due to the impact of neurological dysfunction.

My third research question investigated cognitive abilities of verbal learning and memory, inhibition, and working memory as contributing unique variance to reading comprehension. The SVR model explained a large amount of reading comprehension variance in the PAE group, however, it did not account for the same variance in the FASD group. Kirby and Savage (2008) noted that a simple or reductionist model may not be useful if it does not capture sufficient information about the components of reading ability for all readers. To investigate additional variables that could explain unique variance, hierarchical regression analysis was repeated on each of the PAE and FASD groups respectively. In the PAE group, none of the additional variables contributed unique variance. In the FASD group, verbal short-term memory contributed 10.3% of unique variance when added to the SVR model. This result is consistent with those of Goff et al. (2005) and Cain et al. (2004), who also reported that verbal memory contributed significantly to reading comprehension when added to the SVR model. The percent of additional variance accounted for across these studies ranged from 1 to 6.9%. Also in the FASD group, inhibition contributed 7.4% unique variance. This result is consistent with that of Conners (2009), who reported that inhibition contributed an additional 5 to 10% of variance depending on which decoding term was used in the SVR model. In my study, the contribution of unique variance by verbal memory and inhibition appeared only for the FASD group, indicating these independent variables may impact reading development in this group. Future research utilizing a larger sample size would be important to investigate the relationship of these cognitive variables to the reading development of children with FASDs. As predicted, the measure of working memory investigated in this study did not contribute unique variance. Working memory tasks that require manipulation of linguistic information (e.g., sentences; words) have been more highly correlated with reading comprehension than digit tasks (Cain et al., 2004; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Seigneuric et al., 2000). It would be valuable to use working memory measures closely correlated to reading comprehension and in keeping with the reading research literature in future studies.

The SVR variables together with verbal memory and inhibition did not explain a great amount of reading comprehension variance (38%) in the FASD group, especially in comparison to the PAE group. None of the other variables examined in regression analysis accounted for unique variance including Full Scale IQ, Verbal IQ, Nonverbal IQ, verbal learning, or working memory. It is evident that additional cognitive variables not examined in this study likely impact the reading development of the FASD group and consideration also needs to be given to social and environmental factors (Landry & Smith, 2007; Nation, Snowling, & Clarke, 2007). For example, some children with poor reading comprehension may fall behind because of lack of experience and practice with reading. In early childhood, literacy events such as exposure to print may be limited with respect to the amount and quality of stimulation and support provided. Questions of how child characteristics, both cognitive and social-emotional, contribute to or inhibit gains in reading development need to be investigated.

My fourth research question examined the deficit patterns of poor readers based on individual strengths and weaknesses in decoding and linguistic comprehension. This classification described children with deficits in decoding but with normal linguistic comprehension (specific word reading deficit); children with deficits in linguistic comprehension but not decoding (specific comprehension deficit); children with deficits in both decoding and linguistic comprehension (mixed deficit); and a nonspecified subgroup was comprised of poor readers with adequate performance in both decoding and linguistic comprehension.

Out of the 81 children examined in this study, 13 (36%) identified as having PAE and 32 (71%) as having FASDs were classified in the subgroups utilizing a reading comprehension cut-off score at or below the 16th percentile. In the poor reader subgroups, the majority of children demonstrated weak skills in both word reading and linguistic comprehension. In both the PAE and FASD samples, three-quarters of the children showed weakness in word recognition. Nearly two-thirds of children in the FASD sample and nearly one-half of children in the PAE sample showed weakness in linguistic comprehension. Thus, my expectation was not met for a larger number of children to fall into the category of specific comprehension deficit than the other two categories of specific word reading deficit or mixed deficit. In the FASD group, a small number of children were very poor readers despite their adequate performance in decoding and linguistic comprehension.

Of particular interest were the three children in the nonspecified subgroup who scored below the 10th percentile in reading comprehension even with having scored at or above the 25th percentile in decoding and linguistic comprehension. This subgroup was not predicted by the Simple View of Reading model and a further examination of them was taken. The subgroup was comprised of males in grade three, five and nine; one child's reading was assessed using the WJ-III and two using the WIAT-II; their intellectual abilities were in the average range; all three children had a diagnosis of ADHD. On verbal learning and verbal short-term memory, their scores were adequate. On the CVLT-C, significant weakness was noted on an interference task for two of the children; the third child showed weakness on the WISC-IV working memory measure. Very weak scores were noted on the NEPSY-II inhibition measure for all three children, including extremely low scores for total errors and uncorrected errors; according to the NEPSY-II manual, these process scores are indicative of a child's ability to monitor their performance. The characteristics of poor readers who fall into the nonspecified subgroup merit future research to assist with understanding factors that contribute to poor reading when decoding and linguistic comprehension appear adequate.

In their longitudinal study, Catts et al. (2006) found the subgroup profiles of poor readers were present in early school grades and consistent with those observed in eighth grade. This finding indicated that early identification of weakness in phonological processing and word reading skills as well as linguistic comprehension would be important for early intervention and reading instruction. Other researchers also have recommended the formation of subgroups of readers taking into account word level skills and language development (Megherbi et al., 2006; Nation et al., 2004). These subgroups also speak to the substantial heterogeneity within the population of poor readers and intervention programs need to be tailored to the specific strengths and weaknesses presented by each child (Cain & Oakhill, 2006).

Implications for Educational Practice and Interventions

The SVR model offers a relatively simple framework for teachers to understand and to assess the nature of reading difficulties in children with alcohol exposure based on the component skills of decoding and linguistic comprehension (Catts & Hogan, 2003; Roberts & Scott, 2006). It informs the planning of teaching methods knowing that the processes of word decoding and of comprehension differ. Teaching decoding skills is accomplished through systematic phonics teaching. Children with limited vocabulary and delayed linguistic skills, such as syntax, discourse and conceptual knowledge (Storch & Whitehurst, 2002), need abundant opportunities to strengthen these skills to understand what they read across a variety of genres and topics.

Children with a diagnosis of an FASD demonstrate additional impairments or weaknesses in cognitive processes. Problems displayed in the area of verbal memory such as encoding new information may be addressed by direct instruction in reading strategies of linking new material with previously learned material and elaborating on new concepts. The direct instruction of memory strategies that create organized patterns for learning would be beneficial (e.g., advance organizers) so that children use an active learning style rather than passively reading print. Intervention studies of children with FASDs using rehearsal training improved digit span performance (Loomes, Rasmussen, Pei, Manji, & Andrew, 2008) and using a computerized attention training program improved performance on sustained and selective attention measures (Kerns, MacSween, Vander Wekken, & Gruppuso, 2010). These studies indicate potential for positive effects of strategies training to enhance the learning outcomes of children with alcohol exposure. Successful reading comprehension requires conscious control and cognitive flexibility, skills that often are weak in children with FASDs (Korkman et al., 2003; Rasmussen & Bisanz, 2009). Training attention-control capabilities (e.g., training to maintain on-task thoughts) within the reading context has the potential to improve reading comprehension (McVay & Kane, 2011).

An intervention study by Adnams et al. (2007) reported a systematic classroom language and literacy intervention for third-grade children with FASDs in a South African community. The program was administered by an experienced speech language pathologist and consisted of language therapy alternating with training in phonological awareness and early literacy skills. In comparison to the FASD control group, the FASD intervention group demonstrated significantly greater improvements in targeted areas of syllable manipulation, letter sound knowledge, written letters, word reading, nonword reading, and spelling. The outcome reflected an improvement from preliteracy skill levels averaging two or more years of delay to that of some functional early literacy.

The diagnostic assessment of linguistic comprehension and language skills in children with alcohol exposure is important to assist with the development of Individual Program Plan goals focusing on a child’s identified strengths and weaknesses. Given weak decoding skills identified in the FASD group in my study and weak phonological processing skills reported in a study of adolescents with prenatal alcohol exposure (Korkman et al., 2003), reading interventions may need to include systematic phonics training and instruction in word-level reading skills. More studies are needed to examine the development of phonological processing skills in children with alcohol exposure so as to inform interventions.

There are few studies describing evidence-based reading interventions for children with alcohol exposure. The intent of my study was to provide a better understanding of the cognitive components influencing reading development in children with alcohol exposure so as to inform instruction and evidence-based intervention tailored to their specific needs. The identification of reading achievement as an area of relative strength for some children with alcohol exposure has the potential to use reading skills to scaffold weaker areas of learning development.

Study Limitations

First, my study was a retrospective review of existing clinical data from a single site and there may be selection biases. These findings need to be replicated with other samples of children with prenatal exposure to alcohol. Future studies with larger samples at each age/grade level would be important to evaluate developmental differences in reading comprehension from elementary through high school and to evaluate the effect of both maturational and experiential factors on reading development.

Second, comparisons between studies may be limited if varying methods are used to diagnose FASDs. In my study, the sample was drawn from a pool of children who were prenatally exposed to alcohol. The diagnostic approach was based on the FAS DPN four-digit diagnostic code (Astley & Clarren, 2000; Astley, 2004). However, due to the nature of assessing a referred group of children with complex learning profiles, the measures used by clinicians were variable at times and by age. Several constructs of interest were measured by different tests using Canadian or U.S. norms, creating a problem of comparing scores. In my study a procedure was utilized to merge information from different measures into a single variable if required. This procedure was viewed as conservative in that it likely decreased PAE and FASD group differences because individual scores were adjusted to the combined group mean. As well analyses were repeated on a smaller sample with few combined measures, and these results were consistent with those for the larger sample. The nonequivalence of measures in research likely contributes to differences in conclusions about which components are necessary and sufficient for successful reading comprehension (Cutting & Scarborough, 2006; Keenan et al., 2008). It would be important to utilize consistent measures and specific scores to enhance the reliability and validity of future research. Similarly, it would be valuable to assess decoding skills through non-word measures and phonological processing tasks, and to assess linguistic comprehension skills through different aspects of oral language skills, e.g., narrative skills, to further explore determinants of reading comprehension in children with alcohol exposure.

Third, Engle, Cantor, and Carullo (1992) asserted that digit span was not a good measure for predicting higher-level cognitive tasks such as reading. Digit span "is sensitive to rehearsal, grouping, and recognition of patterns that are idiosyncratic to digits, and these elaborative strategies are probably not generalizable to cognitive tasks, such as reading" (p. 991). The frequently used working memory measure described in reading comprehension research is a complex span task, which combines processing with the temporary storage of information (Daneman & Carpenter, 1980). Individuals perform a series of processing tasks and are asked to remember the product of this processing or to recall separate storage items at the end of the trial. Variations of the reading span task include listening and counting spans (e.g., Siegel & Ryan, 1989) and numbers (e.g., Yuill, Oakhill, & Parkin, 1989). In future studies, it would be valuable to use working memory measures closely correlated with reading comprehension and in keeping with the reading research literature.

Fourth, the influence of issues related to social background was not controlled. Children with alcohol exposure tend to have other negative life factors, (e.g., early environmental risk factors, trauma, foster placements, minority group status, etc.), and it was not possible in this study to evaluate the impact of these factors and their potential contribution to the findings. However, a minimal comparison of adverse life factors versus stable life factors was considered. Regarding postnatal risk factors, nearly 70% of children identified as having PAE were considered to be high risk and 22% at some risk; nearly 47% of children with FASDs were at high risk and 40% at some risk. Thus a large proportion of children in both groups were exposed to potentially negative life factors. Even in light of high risk factors, the PAE group’s mean standard scores on variables of decoding, linguistic comprehension, and reading comprehension were in the average range in contrast to below average mean standard scores for the FASD group.

Fifth, the influence of school programming was not controlled. Based on school reports, 64% of children identified as having PAE and 80% of children with FASDs were identified as in need of individualized program plans or modified educational programs. Thus at the school level a significant proportion of children in the PAE group and even greater number of children in the FASD group received special education services to support their academic development. It was beyond the scope of this study to consider the nature and efficacy of special education interventions on reading outcomes. Beyond examining cognitive factors intrinsic to children, research is needed to better understand the impact of extrinsic variables, such as reading instruction and experience, on reading development.

Sixth, the impact of Attention Deficit Hyperactivity Disorder (ADHD) was not controlled. In the PAE group, 21 (58%) children were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) of which 52% were on medication therapy. In the FASD group, 34 (76%) children were diagnosed with ADHD of which 62% were on medication therapy. Thus a large proportion of children identified with ADHD in both groups were afforded medication therapy.

Comparatively on these adverse risk factors the PAE group and FASD group showed similar challenges, yet the PAE group performed significantly better on cognitive and linguistic measures. These findings suggest that neurocognitive dysfunction had a greater impact on reading development than psycho-social factors in this referred group.

Importance of the Study

This study is unique in examining the reading comprehension of a relatively large sample of children with prenatal exposure to alcohol and in utilizing robust measures of decoding, linguistic comprehension, and reading comprehension. In the referred sample, the finding of 36% of children in the PAE group and 71% of children in the FASD group showing weakness in reading comprehension is striking. These results indicate the need for comprehensive assessment of the linguistic and cognitive components of reading development in children with alcohol exposure so as to inform instruction and interventions needed to target essential skills for reading development. This study contributes to the international research literature using SVR as a model for predicting reading comprehension (Kirby & Savage, 2008; Megherbi, Seigneuric, & Ehrlich, 2006;

Stuart et al., 2008; Verhoeven & Van Leeuwe, 2008) particularly in a referred group of children with prenatal exposure to alcohol. The SVR model was adequate for the PAE group but it was not sufficient for capturing the components of reading ability in the FASD group in this study.

Conclusions

This study provided new information on the nature of reading difficulties in a sample of children with prenatal exposure to alcohol. The Simple View of Reading model offers a relatively simple framework for educators to conceptualize how component skills of decoding and linguistic comprehension influence reading comprehension. Although the Simple View of Reading model explained a large amount of variance in reading comprehension for children in the PAE group, it was not sufficient for explaining reading comprehension in children in the FASD group. Given the measurable differences in decoding, linguistic comprehension and reading comprehension, educators cannot look through the same lens when planning treatment strategies for children identified as having PAE versus those having FASDs. When considering reading instruction and interventions for the latter group, it is not enough to enhance the decoding and linguistic comprehension variables. Particular to children with FASDs, the significant variability identified in cognitive skills such as verbal memory and inhibition highlights the importance of treatment that develops explicit strategies for memory and attentional control within the reading context. Overall the findings suggest that neurological dysfunction impacts reading development in children with FASDs in a unique manner that requires further research to determine the relationship between neurocognitive deficits and reading comprehension.

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APPENDIX A

Question One: Do Group Differences Exist on D, LC, and RC Variables

After adjusting outliers on decoding, linguistic comprehension, and reading comprehension measures, PAE and FASD group means were examined using one-way analysis of variance. As shown in Table A.1 there was a significant difference on group performance with each variable. The effect size, calculated using *Cohen's d*, was medium for decoding, and large for linguistic comprehension and reading comprehension (Cohen, 1988, p. 22).

Question Two: Simple View of Reading as Predictor of Reading Comprehension

The relationship between product, additive and combination versions, respectively, and RC was investigated using Pearson product-moment correlation coefficient, and values interpreted based on Cohen's (1988, pp. 79-81) guidelines. The proportion of variance in RC accounted for by three versions of the SVR is shown in Table A.2. In the PAE group 70% of variance was explained by the product or combination version, and 67% by the additive version. For the FASD group 22% of variance was explained by the product or combination version, and 21% by the additive version. Although the variance explained was significant in both groups, the SVR model clearly explains more of the RC variance for the PAE group than for the FASD group.

Table A.1 Descriptive Statistics of SVR Variables and Effect Size

	PAE		FASD			
	M	SD	M	SD	F	Cohen's d
D	89.97	14.43	81.92	12.90	7.002**	0.59
LC	97.81	12.85	83.87	11.36	26.799***	1.15
RC	92.33	14.67	79.69	9.45	22.032***	1.02

Note: D=Decoding; LC=Linguistic Comprehension; RC=Reading Comprehension
DF = 1, 79: **p <.01; ***p <.001

Table A.2 Variance in RC accounted for by three versions of SVR

Model Version	R^2 PAE	R^2 FASD
Product: RC = D x LC	0.70***	0.22**
Additive: RC = D + LC	0.67***	0.21**
Combination: RC = D + LC + (D x LC)	0.70***	0.22**

Note: Dependent Variable: RC; **p<.01, ***p<.001

To further evaluate the potential interaction effect of diagnosis in each version of the SVR model, regression analysis was utilized. R square change values from these analyses are presented in Tables A.3, A.4, and A.5. There was a difference in the amount of unique variance explained by the SVR model for PAE versus FASD groups. This can be supported by the small but significant additional variance explained by the interaction between diagnosis and product predictor (4.4%), additive predictor (5.9%), and combination predictor (4.4%).

Table A.3 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.150	0.018
	Product Predictor (RC=DxLC)	0.688	.373***
Step 2	Diagnosis	0.692	.028*
	Product Predictor	0.894	.359***
	Diagnosis X Product Predictor	-0.798	.044**

Note: *p < .05; **p<.01; ***p < .001

Table A.4 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.167	0.022
	Additive Predictor (RC=D+LC)	0.656	.341***
Step 2	Diagnosis	1.777	.048**
	Additive Predictor	0.922	.345***
	Diagnosis X Additive Predictor	-1.854	.059**

Note: *p < .05; **p<.01; ***p < .001

Table A.5 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.150	0.018
	Combination Predictor (RC=D+LC+DxLC)	0.688	.373***
Step 2	Diagnosis	0.703	.028*
	Combined Predictor	0.895	.359***
	Diagnosis X Combination Predictor	-0.808	.044**

Note: *p < .05; **p<.01; ***p < .001

APPENDIX B

Question One: Do Group Differences Exist on D, LC, and RC Variables

Analyses were repeated using only the subsample of children in the PAE group (n = 29) and FASD group (n = 29) who had completed the WIAT-II word reading and reading comprehension measures. In this subsample the majority of children had completed the OWLS linguistic comprehension measure. PAE linguistic comprehension variable included OWLS (n=25) and USP (n=4). The FASD linguistic comprehension variable included OWLS (n=24) and USP (n=5). PAE and FASD group means were examined using one-way analysis of variance. As shown in Table B.1 there was a significant difference on group performance with variables of linguistic comprehension and reading comprehension, and approached significant difference with decoding. The effect size, calculated using *Cohen's d*, was medium for decoding, and large for linguistic comprehension and reading comprehension (Cohen, 1988, p. 22).

Question Two: Is SVR Model Valid as Predictor of Reading Comprehension

The relationship between product, additive and combination versions, respectively, and RC was investigated using Pearson product-moment correlation coefficient, and values interpreted based on Cohen's (1988, pp. 79-81) guidelines.

Table B.1 WIAT-II Descriptive Statistics of SVR Variables and Effect Size

	PAE		FASD			
	M	SD	M	SD	F	Cohen's d
D	88.76	13.95	82.34	11.05	3.768*	0.51
LC	98.41	15.09	82.83	13.30	17.418***	1.10
RC	92.03	14.66	79.76	8.18	15.508***	1.03

Note: D=Decoding; LC=Linguistic Comprehension; RC=Reading Comprehension
DF = 1, 56: *p = 0.057; ***p < 0.001

Table B.2 Variance in RC accounted for by three versions of SVR

Model Version	R^2 PAE	R^2 FASD	*r* FASD
Product: RC = D x LC	0.675***	0.06	0.242
Additive: RC = D + LC	0.664***	0.05	0.221
Combination: RC = D + LC + (D x LC)	0.675***	0.06	0.241

Note: Dependent Variable: RC; ***p <.001

Table B.2 shows the proportion of variance in RC accounted for by three versions of the SVR model. In the PAE group 68% of variance was explained by the product or combination version, and 66% by the additive version. The variance was not significant for the FASD group. In this clinical group the smaller sample size showed less variability and more clustering of scores on the RC measure resulting in a restricted range (SD = 8.18) which likely accounted for the insignificant effect. However, Cohen’s guidelines for interpreting the effect size *r* independent of the sample size indicated a medium effect size (1988, p. 22). The SVR model clearly explains more of the RC variance for the PAE group than for the FASD group.

To further evaluate the potential interaction effect of diagnosis in each version of the SVR model, regression analysis was utilized. R square change values from these analyses are presented in Tables B.3, B.4, and B.5. There was a difference in the amount of unique variance explained by the SVR model for PAE versus FASD groups. This is supported by the small but significant additional variance explained by the interaction between diagnosis and product predictor (3.3%), additive predictor (4.5%), and combination predictor (3.3%).

Table B.3 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.137	0.015
	Product Predictor (RC=DxLC)	0.691	.376***
Step 2	Diagnosis	0.588	.020*
	Product Predictor	0.868	.339***
	Diagnosis X Product Predictor	-0.686	.033*

Note: *p < .05; ***p < .001

Table B.4 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.153	0.018
	Additive Predictor (RC=D+LC)	0.662	.347***
Step 2	Diagnosis	1.553	.037*
	Additive Predictor	0.896	.325***
	Diagnosis X Additive Predictor	-1.626	.045**

Note: *p < .05; **p <.01; ***p < .001

Table B.5 Regression Analyses of Diagnosis as Predictor of RC

		β	ΔR^2
Step 1	Diagnosis	-0.137	0.015
	Combination Predictor (RC=D+LC+DxLC)	0.691	.376***
Step 2	Diagnosis	0.598	.020*
	Combined Predictor	0.869	.338***
	Diagnosis X Combination Predictor	-0.695	.033*

Note: *p < .05; ***p < .001