LISTENING COMPREHENSION ABILITIES IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER AND LANGUAGE IMPAIRMENT

by

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A thesis submitted in conformity with the requirements for the degree of Ph.D.
Department of Human Development and Applied Psychology
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Alison Jean McInnes, Ph.D., 2001
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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) and Language Impairment (LI) are two common developmental disorders that have far-reaching effects on children’s academic success and development of social skills. Although ADHD and LI frequently co-occur, relatively little is known about specific patterns of LI associated with ADHD. This study sought to examine language comprehension abilities at the discourse level in children with ADHD and LI, both alone and in combination. It was hypothesized that children with ADHD would have more difficulty than normal children in comprehending less explicit information (i.e., making inferences) and monitoring their own comprehension during challenging listening tasks involving passages in the expository genre, and that children with combined ADHD+LI would show poorer comprehension abilities than children with LI alone. Another objective was to examine verbal and spatial working memory abilities in children with ADHD and LI, and determine whether these skills are associated with listening comprehension.

Standardized measures were used to classify participants into an ADHD (no LI) group, an ADHD+LI group, an LI group, and a Normal control group. Children completed two novel listening comprehension tasks designed to assess 1) comprehension of facts and inferences in expository passages, and 2) the ability to detect errors in sequence or in factual consistency. Results showed that the two LI groups had the most difficulty with listening
comprehension, although contrary to expectations, performance of children with combined
deficits (ADHD+LI) was not worse than that of children with LI alone on the two listening
comprehension tasks. Children with ADHD (no LI) were poorer than normal children at
generating inferences and monitoring comprehension of spoken expository passages, despite
comparable ability to comprehend facts. Children with ADHD, ADHD+LI, and LI showed
significantly poorer verbal and spatial working memory skills compared with normal
children. Spatial memory span was also deficient in these children, however verbal memory
span was impaired only in the two LI groups, not in the ADHD group. Regression analyses
suggested that both verbal and spatial working memory predicted a significant amount of
the variance in listening comprehension performance. Results are discussed with respect to
theoretical, clinical, and educational implications.
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I would first like to acknowledge the ongoing support, input, and encouragement of my committee: To Drs. Rosemary Tannock and Tom Humphries for their expertise in clinical research and their willingness to guide me in a new area of research, to Dr. Carol Musselman for her help early in the project, to Dr. Sheilah Hogg-Johnson for her invaluable contribution the design and analysis process, and to Dr. Dale Willows, who provided both an objective and “devil’s advocate” voice. Thanks also to Dr. Andy Biemiller for his assistance with the vocabulary analyses of the experimental measures, and to Karen Ghelani for her assistance in the inter-rater reliability procedures.

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Chapter 1  

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is the most prevalent and frequently diagnosed disorder among the child psychopathologies, affecting from 3-6% of school age children (AACAP, 1997; Szatmari et al., 1989). ADHD is heterogeneous in its presentation, and frequently co-occurs with other learning disorders including Reading Disability (RD) (August & Garfinkel, 1989; Riccio et al., 1993; Shaywitz et al., 1994; Tannock & Brown, 2000) and Language Impairment (LI) (Cantwell & Baker, 1991; Beitchman et al. 1996; Riccio & Hynd, 1993a: 1996: Westby & Cutler, 1994; Tannock & Schachar, 1996). This heterogeneity presents significant challenges not only for clinicians in determining the best approaches to assessment and treatment, but also for researchers attempting to specify underlying cognitive correlates of ADHD.

Language impairment (LI) appears to be one of the most frequently reported disorders that co-occur with ADHD (Cantwell & Baker, 1991; Love & Thompson, 1988; Cohen et al., 1993, 1998a), however despite this close association, relatively little is known from empirical research about the specific nature and functional outcomes of LI in children with ADHD. It is not clear, for example, whether children with ADHD have a unique profile of language deficits or whether their language impairments are similar in nature and severity to those of children with LI alone with no ADHD.

Of the relatively few studies examining language abilities in children with ADHD, the majority have focused on expressive language skills, mainly with respect to production and organization of spoken discourse (e.g. Zentall. 1988; Tannock et al. 1994: 1996: Oram et al., 1999; Cohen et al., 2000; Vallance et al., 1999). Comprehension of spoken discourse is one aspect of receptive language ability that is essential for daily communication and
academic success, however this area has been overlooked in studies to date. An important issue in the field is that few studies of cognitive and language abilities in children with ADHD have controlled for presence of common comorbid disorders such as LI in their research samples. Given the high rate of co-occurrence of LI and ADHD, an investigation of language abilities requires a controlled design which allows comparison of abilities among groups with ADHD, ADHD+LI, and LI alone.

The primary objective of this research was to investigate listening comprehension abilities for discourse level language in children with ADHD employing a four group design which would address the frequent co-occurrence of LI with ADHD. Four specific aspects of listening comprehension were examined in spoken discourse presented in the expository genre: 1) comprehension of facts, 2) comprehension of inferences, and 3) comprehension monitoring ability, assessed through tasks requiring a) detection of errors in sequenced instructions and b) detection of errors in factual consistency.

A second objective of this research was to investigate the relationship between working memory ability and listening comprehension ability in children with ADHD and LI. The construct of working memory has received considerable attention in recent research regarding the cognitive processes underlying both ADHD and LI, and has also been theorized to play a central role in language functioning and language development.

The following review of the literature will first cover the clinical characteristics and developmental outcomes of ADHD and LI as separate conditions, followed by a discussion of the frequent overlap between ADHD and LI, and issues that arise from this overlap that affect clinical practice and research in ADHD. The discussion will then turn to the two main constructs under investigation in this study: listening comprehension at the discourse level,
and working memory. This section will be followed by a review of pertinent studies to date of working memory, oral language, and discourse abilities in children with ADHD and LI. Critical issues from the literature will then be reviewed with respect to the objectives and research questions guiding this investigation, followed by specific hypotheses.

**Literature Review**

1.1 Introduction to ADHD, SLI and Comorbidity

**Introduction to ADHD: Clinical Characteristics and Outcomes**

ADHD is a symptom complex characterized by behavioural symptoms of observed excess levels of inattention, hyperactivity, and impulsivity, which cannot be attributed to other medical disorders or developmental delay (American Psychiatric Association, 1994). The disorder is observed cross-culturally (Baumgartel et al., 1995; Bird et al., 1988; Wang et al., 1993) and its heritability is well-documented in the literature (Faraone et al, 1995). ADHD is evident during preschool years, with parental reports of children’s hyperactivity, and difficulties with attention control and getting along socially with others.

No specific tests or biological markers have been developed for differential diagnosis of ADHD. Clinical diagnosis of ADHD is based on reports of behavioural symptoms gathered through structured interviews and standardized rating scales in conjunction with information from cognitive, medical, and educational assessments. Using systems such as the DSM-IV taxonomy (APA, 1994), a diagnosis is made if the child’s history and presenting symptoms meet a number of behavioural criteria that are set as a threshold for clinical significance. The currently used DSM-IV system distinguishes two clusters of symptoms, inattention and hyperactivity/impulsivity, which give rise to three
subtypes of ADHD (Lahey et al., 1994; Eiraldi et al, 1997). The first comprises predominantly hyperactive and impulsive behaviours, referred to as the Hyperactive/Impulsive Type. The second subtype is characterized primarily by symptoms of inattention, referred to as the Inattentive Type, and a third subtype involves symptoms of both inattention and hyperactivity/impulsivity, referred to as the Combined Type. Rates of occurrence of the three subtypes documented during epidemiological field trial studies for validation of the DSM-IV diagnostic criteria show the Combined subtype as most prevalent (50-60% of cases), followed by the Inattentive subtype (20-30% of cases), and the Hyperactive/Impulsive subtype (10-20% of cases) (Faraone et al., 2000; Faraone et al., 1998a; Wolraich et al., 1996).

Cardinal behavioural symptoms of ADHD include difficulty sustaining attention and effort in everyday tasks, impulsive behaviour, poor organizational skills, inconsistent task completion, and inappropriate and off-topic communication, frequently referred to as pragmatic language difficulty. These symptoms impair functioning and achievement across social, educational, and occupational situations in both children and adults with ADHD (Zentall, 1993; Faraone et al., 1996). Inconsistent occurrence and severity of symptoms over time and situations is one of the more frustrating and perplexing issues for parents and teachers with regard to day to day management of children with ADHD at home and at school. Social skill difficulties are among the most frequently reported outcomes associated with ADHD. Difficulty cooperating in groups, being excluded by others in play, and difficulty forming friendships (Prizant et al., 1990; Cantwell & Baker, 1987; 1991) are typical problems experienced by children with ADHD.
ADHD varies in clinical presentation with respect to severity, presence of other co-occurring psychopathologies and learning disorders, and its developmental course throughout the lifespan. It has been reported that as many as two thirds of children with ADHD also qualify for other diagnoses, including Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), mood disorders, and Anxiety Disorder (AACAP, 1997). Co-occurring learning disorders such as Reading Disability (RD) and Language Impairments (LI) have been reported to occur in between 25-50% of children with ADHD (see reviews by Faraone et al., 1996; Tannock & Brown, 2000), with varying rates of occurrence that depend on how these disorders are defined and diagnosed. One approach to the issue of frequent co-occurrence of other conditions with ADHD has been to group disorders that have specific deficits in common into clinical subtypes. For example, August & Garfinkel (1989) and Shaywitz et al. (1994) proposed that ADHD comprises two distinct subtypes, a cognitive subtype and a behavioural subtype, with LI and RD more related to the cognitive subtype, and oppositional and conduct disorders (i.e., ODD and CD) more related to the behavioural subtype. Recent evidence supporting this view was provided by Rappaport et al. (1999) in a study showing that long term outcomes of ADHD could be dissociated into different developmental paths that were tied to either cognitive or behavioural factors.

ADHD symptoms persist throughout childhood and adolescence into adulthood. Approximately 65% of children with ADHD retain their diagnosis as adults (Weiss & Hechtman, 1993). Some adults with ADHD show evidence of development of compensations that facilitate improved functioning in social and vocational settings, however the remainder show chronic and pervasive difficulties with social functioning and are at high risk for difficulties with employment, mental illness, accidents, and substance
abuse (AACAP, 1997). It has been reported that children with ADHD are two to three times more likely than normal children to experience academic failure, over half will require special education services, and one third will not complete high school (NIH Consensus Statement 1998; McKinney et al., 1993; Zentall, 1993).

Early clinical and theoretical conceptualizations considered ADHD to be a disruptive behaviour disorder caused primarily by deficient attention control. More recently, ADHD is viewed as a genetically-linked neurodevelopmental disorder characterized by poor behavioural self-regulation, which frequently co-occurs with other learning and behaviour disorders (Douglas, 1999; Barkley, 1997). Considerable research effort has been devoted to isolating a central deficit or set of phenotypic markers that are specific to ADHD. Recently, converging evidence from neuropsychological and neuroimaging studies has supported the theory that impaired executive functions are a consistent correlate of ADHD (Pennington & Ozonoff, 1996; Riccio et al., 1993, Seidman et al. 1997). Within the domain of executive functions, response inhibition has been proposed as the core cognitive deficit (Schachar et al., 2000; Barkley, 1997), however conclusive evidence that response inhibition deficits are specific to ADHD only has not yet emerged (see Tannock, 1998 for review).

ADHD is defined clinically in the DSM-IV with respect to behavioural symptoms of inattention and hyperactivity/impulsivity, however several of the diagnostic symptoms of inattention involve receptive language abilities, such as not seeming to listen when spoken to directly, showing difficulty awaiting turns, and not following through on instructions. Expressive language problems that affect social communication skills fall under the diagnostic category of pragmatic language disorders, and are characteristic symptoms of ADHD (Tannock & Schachar, 1996; Westby & Cutler, 1994). Pragmatic language deficits
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Attention Deficit Hyperactivity Disorder (ADHD) is the most prevalent and frequently diagnosed disorder among the child psychopathologies, affecting from 3-6% of school age children (AACAP, 1997; Szatmari et al., 1989). ADHD is heterogeneous in its presentation, and frequently co-occurs with other learning disorders including Reading Disability (RD) (August & Garfinkel, 1989; Riccio et al., 1993; Shaywitz et al., 1994; Tannock & Brown, 2000) and Language Impairment (LI) (Cantwell & Baker, 1991; Beitchman et al., 1996; Riccio & Hynd, 1993a; 1996; Westby & Cutler, 1994; Tannock & Schachar, 1996). This heterogeneity presents significant challenges not only for clinicians in determining the best approaches to assessment and treatment, but also for researchers attempting to specify underlying cognitive correlates of ADHD.

Language impairment (LI) appears to be one of the most frequently reported disorders that co-occur with ADHD (Cantwell & Baker, 1991; Love & Thompson, 1988; Cohen et al., 1993, 1998a), however despite this close association, relatively little is known from empirical research about the specific nature and functional outcomes of LI in children with ADHD. It is not clear, for example, whether children with ADHD have a unique profile of language deficits or whether their language impairments are similar in nature and severity to those of children with LI alone with no ADHD.

Of the relatively few studies examining language abilities in children with ADHD, the majority have focused on expressive language skills, mainly with respect to production and organization of spoken discourse (e.g. Zentall, 1988; Tannock et al. 1994; 1996; Oram et al., 1999; Cohen et al., 2000; Vallance et al., 1999). Comprehension of spoken discourse is one aspect of receptive language ability that is essential for daily communication and
academic success, however this area has been overlooked in studies to date. An important issue in the field is that few studies of cognitive and language abilities in children with ADHD have controlled for presence of common comorbid disorders such as LI in their research samples. Given the high rate of co-occurrence of LI and ADHD, an investigation of language abilities requires a controlled design which allows comparison of abilities among groups with ADHD, ADHD+LI, and LI alone.

The primary objective of this research was to investigate listening comprehension abilities for discourse level language in children with ADHD employing a four group design which would address the frequent co-occurrence of LI with ADHD. Four specific aspects of listening comprehension were examined in spoken discourse presented in the expository genre: 1) comprehension of facts, 2) comprehension of inferences, and 3) comprehension monitoring ability, assessed through tasks requiring a) detection of errors in sequenced instructions and b) detection of errors in factual consistency.

A second objective of this research was to investigate the relationship between working memory ability and listening comprehension ability in children with ADHD and LI. The construct of working memory has received considerable attention in recent research regarding the cognitive processes underlying both ADHD and LI, and has also been theorized to play a central role in language functioning and language development.

The following review of the literature will first cover the clinical characteristics and developmental outcomes of ADHD and LI as separate conditions, followed by a discussion of the frequent overlap between ADHD and LI, and issues that arise from this overlap that affect clinical practice and research in ADHD. The discussion will then turn to the two main constructs under investigation in this study: listening comprehension at the discourse level,
and working memory. This section will be followed by a review of pertinent studies to date of working memory, oral language, and discourse abilities in children with ADHD and LI. Critical issues from the literature will then be reviewed with respect to the objectives and research questions guiding this investigation, followed by specific hypotheses.

**Literature Review**

1.1 Introduction to ADHD, SLI and Comorbidity

**Introduction to ADHD: Clinical Characteristics and Outcomes**

ADHD is a symptom complex characterized by behavioural symptoms of observed excess levels of inattention, hyperactivity, and impulsivity, which cannot be attributed to other medical disorders or developmental delay (American Psychiatric Association, 1994). The disorder is observed cross-culturally (Baumgartel et al., 1995; Bird et al., 1988; Wang et al., 1993), and its heritability is well-documented in the literature (Faraone et al., 1995). ADHD is evident during preschool years, with parental reports of children's hyperactivity, and difficulties with attention control and getting along socially with others.

No specific tests or biological markers have been developed for differential diagnosis of ADHD. Clinical diagnosis of ADHD is based on reports of behavioural symptoms gathered through structured interviews and standardized rating scales in conjunction with information from cognitive, medical, and educational assessments. Using systems such as the DSM-IV taxonomy (APA, 1994), a diagnosis is made if the child's history and presenting symptoms meet a number of behavioural criteria that are set as a threshold for clinical significance. The currently used DSM-IV system distinguishes two clusters of symptoms, inattention and hyperactivity/impulsivity, which give rise to three
subtypes of ADHD (Lahey et al., 1994; Eiraldi et al, 1997). The first comprises predominantly hyperactive and impulsive behaviours, referred to as the Hyperactive/Impulsive Type. The second subtype is characterized primarily by symptoms of inattention, referred to as the Inattentive Type, and a third subtype involves symptoms of both inattention and hyperactivity/impulsivity, referred to as the Combined Type. Rates of occurrence of the three subtypes documented during epidemiological field trial studies for validation of the DSM-IV diagnostic criteria show the Combined subtype as most prevalent (50-60% of cases), followed by the Inattentive subtype (20-30% of cases), and the Hyperactive/Impulsive subtype (10-20% of cases) (Faraone et al., 2000; Faraone et al., 1998a; Wolraich et al., 1996).

Cardinal behavioural symptoms of ADHD include difficulty sustaining attention and effort in everyday tasks, impulsive behaviour, poor organizational skills, inconsistent task completion, and inappropriate and off-topic communication, frequently referred to as pragmatic language difficulty. These symptoms impair functioning and achievement across social, educational, and occupational situations in both children and adults with ADHD (Zentall, 1993; Faraone et al., 1996). Inconsistent occurrence and severity of symptoms over time and situations is one of the more frustrating and perplexing issues for parents and teachers with regard to day to day management of children with ADHD at home and at school. Social skill difficulties are among the most frequently reported outcomes associated with ADHD. Difficulty cooperating in groups, being excluded by others in play, and difficulty forming friendships (Prizant et al., 1990; Cantwell & Baker, 1987; 1991) are typical problems experienced by children with ADHD.
ADHD varies in clinical presentation with respect to severity, presence of other co-occurring psychopathologies and learning disorders, and its developmental course throughout the lifespan. It has been reported that as many as two thirds of children with ADHD also qualify for other diagnoses, including Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), mood disorders, and Anxiety Disorder (AACAP, 1997). Co-occurring learning disorders such as Reading Disability (RD) and Language Impairments (LI) have been reported to occur in between 25-50% of children with ADHD (see reviews by Faraone et al., 1996; Tannock & Brown, 2000), with varying rates of occurrence that depend on how these disorders are defined and diagnosed. One approach to the issue of frequent co-occurrence of other conditions with ADHD has been to group disorders that have specific deficits in common into clinical subtypes. For example, August & Garfinkel (1989) and Shaywitz et al. (1994) proposed that ADHD comprises two distinct subtypes, a cognitive subtype and a behavioural subtype, with LI and RD more related to the cognitive subtype, and oppositional and conduct disorders (i.e., ODD and CD) more related to the behavioural subtype. Recent evidence supporting this view was provided by Rappaport et al. (1999) in a study showing that long term outcomes of ADHD could be dissociated into different developmental paths that were tied to either cognitive or behavioural factors.

ADHD symptoms persist throughout childhood and adolescence into adulthood. Approximately 65% of children with ADHD retain their diagnosis as adults (Weiss & Hechtman, 1993). Some adults with ADHD show evidence of development of compensations that facilitate improved functioning in social and vocational settings, however the remainder show chronic and pervasive difficulties with social functioning and are at high risk for difficulties with employment, mental illness, accidents, and substance
abuse (AACAP, 1997). It has been reported that children with ADHD are two to three
times more likely than normal children to experience academic failure, over half will require
special education services, and one third will not complete high school (NIH Consensus
Statement 1998; McKinney et al., 1993; Zentall, 1993).

Early clinical and theoretical conceptualizations considered ADHD to be a
disruptive behaviour disorder caused primarily by deficient attention control. More recently,
ADHD is viewed as a genetically-linked neurodevelopmental disorder characterized by poor
behavioural self-regulation, which frequently co-occurs with other learning and behaviour
disorders (Douglas, 1999; Barkley, 1997). Considerable research effort has been devoted to
isolating a central deficit or set of phenotypic markers that are specific to ADHD. Recently,
converging evidence from neuropsychological and neuroimaging studies has supported the
theory that impaired executive functions are a consistent correlate of ADHD (Pennington &
Ozonoff, 1996; Riccio et al., 1993, Seidman et al, 1997). Within the domain of executive
functions, response inhibition has been proposed as the core cognitive deficit (Schachar et
al., 2000; Barkley, 1997), however conclusive evidence that response inhibition deficits are
specific to ADHD only has not yet emerged (see Tannock, 1998 for review).

ADHD is defined clinically in the DSM-IV with respect to behavioural symptoms of
inattention and hyperactivity/impulsivity, however several of the diagnostic symptoms of
inattention involve receptive language abilities, such as not seeming to listen when spoken
to directly, showing difficulty awaiting turns, and not following through on instructions.
Expressive language problems that affect social communication skills fall under the
diagnostic category of pragmatic language disorders, and are characteristic symptoms of
ADHD (Tannock & Schachar, 1996; Westby & Cutler, 1994). Pragmatic language deficits
are illustrated in some of the impulsive behaviours of children with ADHD such as speaking out of turn, talking excessively, using inappropriate vocal loudness, and making off-topic remarks during conversations.

Listening comprehension and information processing skills are another aspect of pragmatic language ability which has not been recognized as possibly being involved with the symptom complex of ADHD. Two behavioural symptoms that are most often reported by parents and teachers are that the ADHD child appears not to listen when spoken to, and does not consistently follow through on instructions and other information that are critical to everyday tasks at home and at school. The DSM-IV diagnostic criteria specify that these behaviours are evident even though the child has adequate comprehension, although little guidance is offered as to how adequate comprehension is verified. Most often, it is assumed by informants that the child is competent enough to comprehend what is said, and these problem behaviours in attention and listening are viewed as being within the child’s conscious control, and are typically interpreted as a form of non-compliance. It is not clear however, whether these symptoms are a consequence of the child’s inattention (conscious or unconscious) or are related to some type of language comprehension difficulty.

Listening comprehension demands vary widely over the course of day to day situations, and it is probable that some listening situations overload children’s processing abilities, resulting in symptoms such as inattention or off-task behaviour. Other potential difficulties with subtle aspects of listening behaviour (i.e., the “pragmatics of listening”) could affect accurate comprehension and recall of information in many situations, such as knowing the amount of processing effort needed to comprehend certain information, knowing what is salient, and making inferences from what is said. Incomplete
comprehension of spoken information could also affect children's ability to respond appropriately to the communications of others, and might be an important factor underlying some of the behavioural symptoms of ADHD that are most impairing to social development and learning. The present study was designed to investigate this possibility.

Introduction to Specific Language Impairment: Clinical Characteristics and Outcomes

Specific Language Impairment (SLI) is a developmental disorder characterized by deficits in both the structural (i.e. grammar and syntax) and functional aspects of language ability that cannot be attributed to hearing loss, developmental delay, oral motor dysfunction, neurological disorders, or disorders of impaired social interaction (e.g., autism) (Leonard, 1998). SLI is prevalent in approximately 7% of Kindergarten age children (Tomblin et al., 1997), and affects more males than females. There is a tendency for SLI to concentrate in families (Tomblin et al., 1994; Tallal et al., 1989a), however not all children with SLI have positive family histories. SLI is however often associated with family histories of other learning disabilities, such as Reading Disability RD (Scarborough et al., 1990; 1991).

SLI is most often identified during the preschool years, and typically arises from parent concerns over slow and/or abnormal development of speech and language skills. During this developmental period, children with SLI demonstrate difficulty mastering the structural aspects of mature language formulation, and may also show concomitant problems with development of concepts and/or phonological difficulties that affect speech intelligibility. Some children improve with specific intervention and do not experience long
term consequences of their early speech/language delay (Bishop & Edmunston, 1987). Others continue to require speech/language intervention throughout their school careers. In another group, preschool speech/language deficits appear to normalize by approximately age 5 when children enter school, and resurface later in the form of difficulties with reading and written language, as suggested by longitudinal studies by Scarborough (1990; 1991), Kahmi & Catts (1989), and Catts (1991). Further support for the notion of SLI as a lifelong condition comes from other longitudinal studies that have found persistence of language deficits through adolescence (Aram, Ekelman, & Nation, 1984; Stothard et al., 1998) and into young adulthood (Johnson et al., 1999).

Considerable debate has occurred in the field over the last 10-15 years regarding whether SLI warrants recognition as a specific developmental syndrome (Leonard, 1991) or whether children with language impairments represent the lower extension of the normal distribution of language abilities. Even as defined by the above exclusionary criteria, SLI is heterogeneous in its presentation. There have been several attempts to subtype language deficits within SLI according to varying predominance of receptive, expressive, semantic, syntactic, and/or pragmatic deficits in language functioning (Rapin & Allen, 1988; Conti-Ramsden & Botting, 1999), however these systems have yet to be consistently adopted in clinical practice and research.

Diagnosis of SLI is typically made using standardized and non-standardized approaches to assessment, some of which are designed to rule out other possible causes of language deficits, such as developmental delay and hearing loss. Diagnostic criteria related to performance on standardized norm-referenced language tests vary in research and clinical practice, however usually range between 1 and 1.5 standard deviations below the mean for
age on at least 2 tests of semantic, morphological, and/or syntactic ability (Leonard, 1998). This represents a shift from earlier criteria of standard language test scores at -2 standard deviations below the mean applied in many research and clinical settings, resulting in the current inclusion of children with more moderate language impairments within the diagnostic category of SLI.

The effects of SLI are far-reaching with respect to many aspects of daily living, including development of social skills, literacy skills, and vocational skills (Leonard, 1998; Wallach and Miller, 1988; Catts, 1993; Bashir et al., 1992). There are currently no specific phenotypic markers for SLI that have been confirmed by research to date, although several branches of research have focused on determining underlying causal factors associated with SLI, including investigations of nonverbal cognitive deficits (Johnston, 1991; 1999; Bishop, 1992), auditory temporal processing deficits (Tallal et al., 1985a; 1985b), early history of otitis media with effusion (OME) (Friel-Patti et al., 1990), slow information processing (Kail et al., 1994), and phonological working memory deficits (Gathercole & Baddeley, 1990a; 1993).

The above brief review of SLI is intended as a point of reference for the present study which will examine children with ADHD and LI. As it is not known whether the language impairments that co-occur with ADHD are similar in nature and severity to language deficits associated with SLI, these will be referred to using the more generic term Language Impairment (LI) for the remainder of this dissertation.
Clinical Overlap of ADHD with Language Impairment and Learning Disorders

ADHD has a high rate of co-occurrence with learning disorders such as Reading Disability (RD) and Language Impairment (LI), with prevalence ranging from 25-50% as reported in early and recent reviews (Shaywitz et al. 1994; Cantwell & Baker, 1987; Prizant et al., 1990; Faraone et al., 1996; Riccio, Gonzalez, & Hynd, 1993; Tannock & Brown, 2000). This broad range likely reflects variations in measurement and classification criteria for LD, RD, and LI across studies. There is also a high rate of co-occurrence among Learning Disorders (LD), RD, and LI in children without ADHD symptoms, with each of these disorders themselves heterogeneous in their presentation. Clinicians across disciplines have acknowledged the close overlap among these disorders by adopting diagnostic labels such as “language-based learning disability” (Wiig & Semel, 1980; Kahmi & Catts, 1989) and “language based learning disorders” as more accurate representations of the disability (Beitchman & Young, 1997; AACAP, 1998).

A major problem for researchers in assessing the nature of other disorders co-occurring with ADHD is the lack of clear phenotypic markers for some of the most commonly associated disorders. Stated another way, there are few isolable constructs that can be used to reliably dissociate the different disorders in clinical assessments that are used for group classification in ADHD research. Reading disability (RD) appears to be more readily distinguishable as a co-occurring disorder than LI and LD. Deficits in phonological awareness and decoding of pseudowords have been validated over many studies as phenotypic markers for RD (Wagner & Torgeson, 1987; Rack et al., 1992), such that presence of RD can be easily demonstrated using specific tasks in brief clinical assessments. This factor has allowed a clearer analysis of the converging evidence from empirical studies.
that RD is a distinct disorder that co-occurs with ADHD, with its own etiological basis (Wood & Felton, 1994; Pennington et al., 1993).

The study by Pennington et al. (1993) raised a provocative issue regarding categorical diagnoses of ADHD and causal relationships among comorbid learning disorders. Using a factorial design, a double dissociation was found between RD and ADHD, with phonological awareness measures identifying presence of RD, and executive function measures used to confirm presence of ADHD. However, the group of children classified as ADHD+RD showed clear evidence of the phonological deficits associated with RD but did not show expected deficits on the executive function tests. This finding was interpreted as a confirmation of the “phenocopy hypothesis” of comorbidity, in which the combined ADHD+RD group had behavioural symptoms of ADHD that appeared to be secondary to RD. While this profile may not apply to all children with ADHD and comorbid disorders, given the frequent overlap of functional deficits and school performance outcomes associated with ADHD, RD, LI, and LD, there may be some children whose ADHD symptoms are in part related to the academic and social difficulties associated with these disorders.

Clinical Issues Pertinent to Methodology in ADHD Research

Several methodological issues arise from research involving children with ADHD which can potentially affect the reliability and generalizability of findings. These are 1) issues related to research samples, such as referred/clinical versus community samples, and unidentified presence of co-occurring disorders, and 2) issues associated with diagnostic instruments and procedures used to classify children with both ADHD and LI.
Studies cited in the literature have tended to rely mainly on clinical samples, a practice which has been criticized with respect to potential bias toward more severe cases (Shaywitz et al., 1994). Clinical samples are also more likely to include children with comorbid disorders, therefore involving more severe functional problems with behaviour and learning (Cohen et al., 1998a; 1998b). Alternately, non-clinical samples may include children whose symptoms lie in the borderline range of clinical significance. Another related problem is that many studies of ADHD have not been designed at the outset to control for presence of co-occurring disorders in research participants (Barkley, 1997). Cohen et al. (1993) have reported that LI tends to be overlooked during assessment protocols in clinics because the focus is more likely to be on behavioural concerns. This common occurrence in clinics has implications for both treatment approaches and research. Beyond the serious educational and treatment implications of failing to identify LI in children with ADHD, consequences in research include possible misinterpretation of ADHD symptoms which may be associated with specific language deficits, and misattribution of performance deficits to ADHD.

Another methodological issue involves how both ADHD and LI are operationally defined and measured for group classification purposes. Research samples of children with ADHD continue to rely primarily on informant rating scales to confirm presence of ADHD, with no definitive diagnostic test for ADHD. With regard to children with LI, language deficits vary broadly in type, severity, and functional outcomes. In most studies, standardized tests are used to assess basic receptive and expressive language skills with respect to vocabulary, grammar, and syntax, using criteria to identify clinically significant LI. However, clinical criteria may vary relative to cognitive-referencing (i.e., Stark and
Tallal, 1981) or language-age referencing approaches to assessment, which can significantly affect the composition of samples in studies involving LI children (Plante, 1998). As clinical practices tend to drive service delivery, they in turn determine availability of clinical samples from which research samples of SLI and other participants are drawn.

One further issue associated with testing and clinical criteria associated with LI arises from concerns that not all language tests assess the same skills or underlying language constructs. Given the wide range of available test instruments, each focusing on different sets of language constructs and tasks, differences can exist across research samples identified as LI that are attributable to the specific measures used to classify them. Second, the validity and reliability of many standardized language tests have been criticized (e.g. McCauley & Swisher, 1984). Third, most standardized language tasks are designed to be as context-free as possible in order to isolate basic language abilities, and do not assess functional or higher level communication abilities involving application of language skills in dynamic contexts.

In ADHD research, even if language tests are routinely administered to research participants, an additional concern is the possibility that LI may be ruled out in children with ADHD and average language test scores, when they may in fact have language deficits not demonstrated in the tests administered. Much of the research regarding language skills in ADHD has focused on skills at the discourse level. However, it is likely that higher level discourse deficits will be missed in ADHD children for whom basic language impairments have been ruled out by average language scores, since these skills are not typically assessed in standardized tests.
Clinically, overestimation of language abilities in children with ADHD has potentially important consequences regarding efficacy of interventions involving talking and listening. In research, the assumption that LI is not a factor in ADHD participants would also have implications for interpretations of findings related to specific cognitive or functional skills, or in studies evaluating the effectiveness of treatment programs for ADHD (e.g. social skills programs and counseling interventions) that rely on intact language and discourse processing abilities. As research samples are often drawn from clinical samples, these issues underscore the need for clinical protocols to include language assessments which address both basic and discourse level language abilities.

1.2: Language Comprehension and Working Memory

The next section will present background information regarding the two main constructs under investigation in this study, listening comprehension for discourse level language, and working memory.

Comprehension of Spoken Discourse - Linguistic and Cognitive Processes

In the introduction to this thesis, it was noted that some research to date has addressed discourse production skills of children with ADHD, whereas the area of discourse processing, specifically, listening comprehension has not been studied in depth. This discussion will now turn to background information regarding models and processes involved in comprehension of discourse that are relevant to this investigation.

As mentioned in the introduction to this thesis, well-developed ability to process spoken discourse is essential for successful social interactions and academic achievement (Wallach & Miller, 1988; Spinelli & Ripich, 1991; Westby, 1991). Discourse can be defined
as a reciprocal communicative exchange between individuals which typically involves propositions that extend over two or more utterances. Discourse is organized by speakers and listeners according to the purpose of the communication. Conversations are organized in turn-taking exchanges between two individuals or within small groups, and are typically informal in style with familiar content. Narrative discourse involves true or fictitious event descriptions organized in a story framework, and occurs both in spoken and in print form.

Expository discourse involves explanation of new information or assertion of a point of view, and is used in the spoken and written language of instruction (e.g., lessons and lectures, textbooks, encyclopedias).

Samuels (1987) separates processes involved with listening comprehension into “inside the head” and “outside the head” factors, which together determine overall listening comprehension outcomes. Inside the head factors refer to variables such as the individual’s basic abilities in language and cognitive domains, their background fund of knowledge, and their motivation in the listening task. Higher level individual skills include recognizing and using context to aid comprehension, and using metacognitive strategies to problem-solve when information is challenging. Outside the head factors refer to variables specific to the discourse such as topic familiarity, genre or style of presentation, information complexity, and the context in which it is being heard. This separation of underlying factors in comprehension facilitates the analysis of listening comprehension in children whose performance is compromised by some “inside the head” factors. Furthermore, it provides a framework from which task difficulty can be analyzed and controlled, in both clinical and research applications.
From a cognitive perspective, discourse is viewed with respect to the knowledge, processes, and skills required to produce and comprehend it. Models of discourse comprehension have been developed mainly from research in reading comprehension, most involving representations of hierarchically organized processing modules with information processed from lower linguistic to higher conceptual levels. One model proposed by Frederiksen et al., (1990) conceptualizes discourse comprehension as comprising three main processing levels. The first level involves processing of language structures (i.e., words, syntactic patterns) which are then mapped upward onto the next level where individual propositions (ideas) are processed and interpreted. At this second level, logical relationships are determined by the listener or reader, and inferences are made that connect implicit meanings from adjacent propositions. These “products” of the comprehension process are then mapped onto broader conceptual frames, where they are integrated with previous knowledge and stored in long term memory.

Earlier models of comprehension assumed a relatively fixed and passive sequence of processing where information was processed from lower to higher levels (i.e., bottom-up direction) (Kintsch, 1988). According to this view, lower level processing deficits would constrain higher level comprehension processes such as inferencing and reasoning. In contrast, top-down processing involved processing that was directed by the listener’s expectations of the listening or reading context and prior knowledge. Currently, comprehension is considered to be more of an active and constructive process that involves both top-down and bottom-up flow of processing functions. Frederiksen et al., (1990) propose that listeners can self-direct information processing by employing control strategies selected to suit the context of the discourse, their own goals regarding the
discourse, background knowledge, and the perceived need to monitor the information to ensure comprehension. This view would appear to implicate a major role for executive functions in these more self-directed aspects of comprehension.

Clinically, comprehension of discourse requires intact functioning of basic language skills as well as the ability to process discourse elements such as cohesive devices used to connect propositions within a text or in spoken messages (Westby, 1991). Complexity of discourse varies with respect to the level of vocabulary used, number of propositions, syntactic complexity, and genre, which together influence comprehension skills in both normal listeners and listeners with LI (Wallach & Miller, 1988; Wiig & Semel, 1980; Englert et al., 1988). Additionally, individual differences in verbal working memory skills and the ability to sustain attention also affect discourse comprehension (Wiig & Semel, 1980; Just & Carpenter, 1992).

Two comprehension skills that are typically assessed clinically in discourse level tasks are comprehension of facts (i.e., direct propositions) and the ability to infer meanings from specific propositions in spoken discourse or in a text. According to the model of Frederiksen et al. (1990), propositions are assertions that are explicitly stated in the text, which can be factual in nature or assertions of opinion. Inferences are understood by making implicit connections among propositions after each proposition has been processed semantically and syntactically. Inferencing is also highly influenced by basic linguistic factors such as vocabulary difficulty and the degree of syntactic complexity used in propositions contained in the discourse (Westby, 1991).

A third skill involved in discourse comprehension is comprehension monitoring, which refers to the ability to consciously reflect on information that is being processed with
respect to factors such as its grammatical accuracy, coherence, ambiguity, or its overall complexity and novelty. Comprehension monitoring can be considered within the domain of metacognitive skills, which are critical for successful processing of both social and instructional discourse (Dollaghan, 1987). Effective comprehension monitoring requires maintenance of “on-line” processing and critical evaluation of both lower level (i.e., syntactic accuracy) and higher level (cohesion) aspects of discourse, and in more complex listening conditions requires increased degrees of self-regulation. Possible outcomes of comprehension monitoring in communicative interactions are for example, the listener querying why a particular word was used to convey a concept, or judging that an explanation was confusing or illogical. In natural communication contexts, a “communication breakdown” signaled by comprehension monitoring leads to a “communication repair” in which the listener asks for repetition or the speaker adjusts the message to make it more comprehensible.

Dollaghan (1987) provides a task analysis of comprehension monitoring in listening conditions. Initially, the listener constructs a mental representation of the meaning of a message, and then decides whether it makes sense or whether there is a problem based on a perceived ambiguity or on something novel within the message. This process involves applying an individually determined criterion and devoting a sufficient amount of processing effort to the task. Judgments that messages are ambiguous might lead to a request for clarification from the speaker, whereas judgments regarding novelty might result in increased processing effort applied to comprehending the information. Evidence from studies of comprehension monitoring in adults suggests that some listeners and readers engage only in superficial evaluation when processing information, and fail to apply
sufficient processing effort to ensuring they understand what they have heard or read.
(Glenberg & Epstein, 1987). Or alternately, if they decide not to evaluate the information in terms of its adequacy, they may uncritically accept the first meaning they attach to it, and misunderstand without realizing it (Pressley et al., 1990). These comprehension monitoring processes would appear to require a number of executive control strategies, including working memory, as information that was being questioned would have to held in mind while the listener was judging its comprehensibility.

There are no currently available standardized tests of comprehension monitoring, and so assessment of this skill must be developed from previous research methodology. Comprehension monitoring has been studied primarily in the area of reading comprehension in samples of normal and learning disabled children. One task that has been used across several studies was developed from an error detection paradigm (Markman, 1979; Markman & Gorin, 1981; Zabrucky & Ratner, 1990), which was later adapted to assess comprehension monitoring in listening by Walczyk & Hall (1989a). When the error detection paradigm is applied to a listening comprehension task, a contrived inconsistency is placed within a spoken passage to assess the child's ability to detect errors in meaning, and the child is asked to listen carefully and report any errors heard. This task appeared to be potentially useful in assessing comprehension monitoring in children with ADHD and LI, because of its novelty and the inherent motivational aspects of finding a problem and reporting it. The task also involves minimal requirements for extended explanations, which would not tax the expressive language weaknesses of children with LI.
Working Memory

Working memory is a multidimensional cognitive construct that underlies several complex cognitive functions, including language processing and reading. Working memory has been referred to as a “mental workspace” where information is held for brief periods of time while being used in more complex mental operations such as reasoning and problem-solving. Verbal working memory involves holding linguistic detail in mind, while non-verbal working memory involves holding visual or spatial information during cognitive tasks. Both aspects of working memory have been examined in recent studies of normal language processes (Gathercole & Baddeley, 1993), reading disability (Swanson, 1999; Nation et al., 1999), psychiatric disorders (Karetekin & Asarnow, 1998; Russell et al., 1996), and school achievement (Gathercole & Pickering, 2000).

Two models of working memory are particularly relevant to investigations of language comprehension and information processing. Baddeley’s (1986) model conceptualizes working memory as a self-contained system that is comprised of a central executive component that coordinates and controls information processing, and two storage components that are each specialized for short term storage of visual and verbal information. Verbal information is held in a phonological memory store referred to as the “phonological loop”, where it is maintained using processes such as subvocal rehearsal. Verbal working memory capacity according to this model refers to the amount of verbal information that can be stored by the phonological loop to serve the processing functions that are being carried out by the central executive. Visual and spatial information are held in the visual storage component, referred to as the “visual-spatial sketchpad”, which serves
that central executive in a similar manner when a processing task requires visual-spatial working memory.

The model of Just & Carpenter (Daneman & Carpenter, 1980; Just & Carpenter, 1992) conceptualizes working memory somewhat differently. In this model, more generalized storage and processing functions are thought to operate simultaneously and in a mutually dependent manner, but are considered to be constrained by each individual’s working memory capacity. Simple comprehension tasks that require less processing will allow more storage of information, however more complex tasks that require continuous coordination of processing and storage functions may place such high demands on the working memory system that a tradeoff will occur toward processing functions, leaving fewer resources available for short term information storage. In this situation, the individual will not be as able to store the intermediate and final “products” of comprehension (i.e., comprehending propositions and inferences) which will in turn limit how well the information can be integrated within previous knowledge. According to this model, individual differences in working memory capacity are what determine individual differences in comprehension ability.

In Baddeley’s model, verbal and spatial aspects of working memory are represented as separate and functionally distinct storage components. Extensive evidence supports the importance of the phonological loop (i.e., verbal working memory) in language comprehension (Gathercole & Baddeley, 1993), however less is known about whether spatial working memory plays a role in this process. Current models of normal reading comprehension processes for narrative texts suggest that working memory is used to develop visual-spatial representations of characters and events in texts called “situation
models', which are integral to successful comprehension (Graesser et al., 1994; Haenggi et al., 1995). Evidence from the many studies of visual-spatial abilities in children with SLI (reviewed below) also supports the idea that visual-spatial skills may be associated with language processing, however these investigations did not set out to examine visual-spatial skills from a working memory perspective, and tasks used across studies to assess visual processing skills vary in their working memory demands. Therefore, while there appears to be an association between visual-spatial processing and language comprehension, the specific role of spatial working memory deficits in language processing has yet to be determined.

One recent study by Pickering et al., (1998) may be the first to suggest that spatial working memory plays a role in language processing, presenting evidence that although verbal and spatial aspects of working memory have distinct functions and operate independently from each other, their function appeared to overlap in language tasks involving serially ordered stimuli. This finding suggests that spatial working memory may play a role in certain types of language tasks that involve processing of sequential information. As this study sought to examine children’s ability to comprehend discourse, which requires comprehending sequences of connected propositions, it was considered important to assess the roles of both verbal and spatial aspects of working memory in this process.

1.3: Studies of Cognitive and Language Abilities in Children with ADHD and LI

Working Memory Abilities in Children with ADHD
Working memory is one of two main cognitive constructs currently of interest in ADHD research, the other being response inhibition (Barkley, 1997, Schachar et al., 2000). While there has been extensive study of response inhibition (see Tannock, 1998 for review), working memory has only recently received attention in studies involving children with ADHD. Norrelgen et al. (1999) recently reported evidence of poor phonological working memory in children with ADHD and developmental coordination deficits in tasks requiring repetition of multi-syllabic nonwords. Mariani & Barkley (1997) also found poorer verbal working memory as measured by backward digit span in children with ADHD compared with normal children, however these results were not replicated by Karatekin & Asarnow, (1998) who found only marginal differences between ADHD and normal children on this task. Spatial working memory deficits have also been implicated in ADHD in tasks such as delayed reproduction of a complex figure such as the Rey-Osterreith task (Seidman et al., 1995), tasks assessing memory for spatial locations (Karatekin & Asarnow, 1998), visual-motor integration (Cohen et al, 2000), and in computerized spatial span and working memory tasks from the CANTAB neuropsychological battery (Kempton et al., 1999; Williams et al., 2000; Sahakian & Owen, 1992).

Two recent studies employing factorial designs examined working memory abilities in samples of children with ADHD and LI. A study by Cohen et al., (2000) found that performance on working memory measures was more closely related to the presence of LI than to ADHD, regardless of whether the measures were verbal or non-verbal. Another study by Williams et al. (2000) involving relatively small groups of 6 year old children with SLI and ADHD found evidence of reduced spatial spans and spatial working memory abilities in the ADHD children that were considered distinct from their language deficits.
Two important issues arising from these preliminary findings regarding working memory are the effect of variations in the spatial tasks with respect to their specific processing demands, and the effect of co-occurring disorders such as LI on interpretation of results.

**Oral Discourse Skills of Children with ADHD**

In studies of language abilities in children with ADHD, it is important initially to distinguish between basic and higher level language skills. Basic language skills refer to comprehension and production of basic rule-governed structural aspects of language such as vocabulary, grammatical forms, and syntactic patterns, which are typically the focus of standardized language tests. Higher level language skills refer to skills in processing and producing discourse in spoken and written modalities.

A related issue concerns the nature of language deficits in clinical presentations of ADHD+LI, which would involve the children referred to in the literature as having ADHD with co-occurring LI (Cohen et al., 1993). These children will have language skills impaired at the basic level, as identified through their scores on standardized language tests. They will also show higher level deficits in language production that signal the pragmatic language deficits associated with ADHD. Basic language impairments involving semantics, grammar, and syntax are considered to be associated more with factors underlying other cognitive learning disorders, such as RD, than with ADHD itself (Tannock & Schachar, 1996, Shaywitz et al., 1994), which is consistent with other perspectives in the field that connect RD and SLI (Kahmi & Catts, 1989; Catts, 1993). Since discourse production skills depend on intact grammatical and syntactic skills, children with ADHD+LI would be likely to show discourse production deficits that are also associated with basic deficits in processing the structural components of language. The pragmatic language deficits and
discourse production problems characteristic of ADHD are higher level processes that are considered to reflect the underlying executive control and self-regulation deficits that are considered to be central to ADHD (Westby & Cutler, 1994; Tannock & Schachar, 1996). Therefore, children with ADHD+LI may show a greater degree of overall language dysfunction associated with their ADHD than children with LI only.

Children with ADHD have been found to have more difficulty than normal children in tasks that involve elicited language or that require planning and organized formulation of discourse. A recent study by Oram et al. (1999) examined ADHD children’s performance on subtests of the Clinical Examination of Language Fundamentals-Revised (CELF-R) (Semel et al., 1987), which is a standardized test of basic language ability and an earlier edition of the CELF-3 (Semel et al., 1995) used as a classification measure for LI in this study. ADHD children had particular difficulty with one task where they were required to make up a sentence with a specific stimulus word. The words were common clause-combining terms (e.g., after, until, unless), with the goal of the task being to elicit complex sentences. The ADHD children’s scores on this task were significantly poorer than normal children’s, despite average scores on other language subtests. Analysis of their error patterns suggested that task performance differences of the ADHD group with respect to impulsive responding and an ineffective pragmatic approach to the task were related to their poorer scores.

In studies of discourse production skills involving oral retelling of narratives, (Tannock et al., 1993; Purvis & Tannock, 1997), children with ADHD were found to produce less overall verbal output and insufficient elaborative detail and background information for the listener, and their narratives contained fewer discourse markers for
cohesion, organization, and referencing compared with those of normal children. Vallance et al. (1999) also found poorer organization and cohesion of oral stories elicited from pictures in children with LI and psychiatric disorders, 45% of whom had a diagnosis of ADHD. In an earlier study, Zentall (1988) found that responses of children with ADHD in elicited language tasks were less well formulated, briefer, and contained less critical detail than their spontaneous language recorded between tasks. These findings suggest that children with ADHD have more difficulty than normal children with language formulation in tasks where oral language is elicited with specific constraints imposed regarding content and formulation.

With regard to processing language at the discourse level, children with ADHD have been found to have variable difficulty. Tannock et al. (1993) and Purvis & Tannock (1997) found that although ADHD children's narrative production skills were poor, their comprehension of factual detail from stories was comparable to that of normal subjects. Earlier studies of ADHD children's ability to process instructional language found that they had more difficulty comprehending spoken information with higher levels of detail or in conditions of competing background noise (Zentall et al., 1983; Shroyer & Zentall, 1986).

Two other studies involving reading comprehension and information processing are relevant to the design of this study, and offer insight into other aspects of language processing in children with ADHD. Brock & Knapp (1996) used cloze tasks and verbal reporting of main ideas from expository passages to assess reading comprehension skills in children with ADHD. Comprehension monitoring of reading was also assessed using children's self-evaluations of how well they thought they had understood the passages. Their results indicated poorer overall reading comprehension performance in the ADHD
group compared with a normal group despite their average word identification skills, but no differences between the ADHD and normal groups on the comprehension monitoring measure. Although this study was one of the first to suggest that children with ADHD have difficulties with comprehension, specifically in reading, one problem with this study concerned the requirement for extended open-ended responses to explain main ideas contained in the reading passages. ADHD children might have attained lower scores because they had more difficulty formulating their explanations of the content in the passages. Also, the use of self-reporting as a comprehension monitoring measure is of questionable reliability, since comprehension monitoring is a metacognitive skill which requires vigilance and self-regulatory skills (Dollahan, 1987), both of which are poorly developed in children with ADHD.

One interesting aspect of the Brock & Knapp study is their attempt to differentiate two levels of processing difficulty by comparing children’s performance on cloze tasks (lower processing effort) versus verbal explanations of main ideas from the passages (higher processing effort). Although their data did not show performance differences in reading comprehension related to the two levels of processing effort, this issue may be relevant to the evaluation of listening comprehension, since long and complex spoken information cannot be as easily reviewed as with reading. The notion of processing effort was also addressed in a study by Carte et al. (1996) in which children with ADHD were tested on various cognitive, motor, language, and executive function tasks. Children with ADHD were found to have more difficulty than normal controls on tasks involving controlled processing and self-regulation of processing speed. Results were interpreted to reflect different performance patterns of ADHD children under different task demands. The
relationship between controlled processing and language comprehension has not been explored in children with ADHD, however listening tasks that require vigilance and monitoring of complex information would be expected to be difficult for children with self-regulation deficits, as they would demand greater control of processing functions directed by the listener.

Overall, language skills in children with ADHD have been studied primarily from the perspective of discourse production, with evidence to date suggesting that ADHD children display deficits in their ability to organize and formulate oral discourse. There may also be parallel deficits in discourse comprehension in children with ADHD involving the organizational approach they apply to the task of listening. Successful comprehension is the product of coordinated flow of information in both bottom-up and top-down directions, which is consciously controlled and monitored by the listener (Frederiksen et al., 1990), skills which would appear to be within the domain of executive functions. Difficulties in self-regulation and controlled processing in individuals with executive function deficits would disrupt performance of tasks requiring organization and monitoring (Ylvisaker & DeBonis, 2000), frequently reported difficulties which may also be associated with the poor and inconsistent listening behaviours in children with ADHD.

**Working Memory Abilities in Children with LI**

There has been a long standing controversy over the nature of the relationship between language deficits and cognitive abilities in children with SLI, which has had an impact on clinical assessment, treatment, and research practices (Swisher et al., 1994; Plante, 1998). Before discussing current views of working memory in children with SLI, a
brief summary of the above issue will provide a context to understand how conceptualizations of SLI have evolved over the last 20 years.

Early discrepancy-based definitions of SLI (e.g., Stark & Tallal, 1981) were motivated by the need for more systematic investigation of children with language and reading disabilities. In research, there was a need to separate samples of children whose LI was associated with other developmental disabilities from children whose only evident impairment was in receptive or expressive language. Therefore, a clinical diagnosis of SLI required non-verbal intelligence scores to be within one standard deviation from the mean (i.e., a composite Performance IQ score between 85 and 115). Considerable debate has ensued in the field regarding the appropriateness of excluding large numbers of children from being diagnosed with SLI, who show both language and cognitive deficits but who meet criteria for neither SLI nor developmental delay (Lahey, 1990; Leonard, 1998). However, despite this continuing controversy, discrepancy formulas involving non-verbal IQ and language ability scores continue to be applied in clinical practice and in research (Plante, 1998).

Other reviews have raised theoretically-based questions about the validity of using a discrepancy model for clinical and research practices regarding SLI, and present a convincing picture that many children with SLI do show non-verbal cognitive deficits that may be important correlates of their language deficits, even when their nonverbal IQ scores are within the normal range (Bishop, 1992; Johnston 1991; 1999). Nonverbal cognitive deficits in SLI children have been reported in studies assessing both perceptual and higher level visual-spatial skills, including spatial orientation skills, visual sequential memory, spatial memory, and use of mental imagery during language comprehension (see Leonard
(1998) for review). However, it has also been pointed out by Johnston (1991) that not all children with SLI demonstrate these deficits.

Bishop (1992) suggested that the key to observed discrepancies in SLI children's performance on non-verbal cognitive tasks may lie in the nature of the processing demands of the tasks themselves rather than in individual differences in cognitive ability. Normal performance on some visual processing tasks could be explained by relatively low processing demands, for example in tasks where visual information stays within view and problems can be approached using static mental representations. However, in tasks where critical information is transient (e.g., such as in a delayed visual recall task), mental representations must be formed quickly and held in mind while the task is being completed. Successful task performance would in this case require the individual to be able to meet the working memory demands of the task. Working memory demands would add significantly to task complexity, in contrast to rote memory demands which would be less challenging.

Several recent studies have provided evidence of a strong link between language performance and verbal working memory abilities in children with SLI. Deficits in verbal working memory have been associated with performance on tasks involving non-word repetition (Gathercole & Baddeley, 1990), cross-modality processing (Gillam et al., 1998), processing competing sentences (Ellis Weismer et al., 1999) and sentence comprehension (Montgomery, 1995a; 1995b; 2000). Baddeley et al. (1998) have proposed that a central deficit in phonological (i.e., verbal) working memory capacity may be a primary factor associated with the language processing and production deficits in children with delayed language and reading abilities, and may also be responsible for slow rate of acquisition of vocabulary and the basic structural components of language.
Cohen et al., (2000) recently reported findings that working memory measures were strongly associated with an LI factor in a large sample of children with LI associated with ADHD and other psychiatric disorders. Findings of this study also showed that performance on both non-verbal and verbal working memory tasks was linked to LI. No other studies to date have specifically examined non-verbal working memory in children with SLI.

The reconceptualizing of research designs and tasks within a working memory perspective in these recent studies may help to resolve the inconclusive findings of earlier studies that were attempting to dissociate language from cognitive deficits in SLI children. The above recent findings connecting working memory deficits to information processing deficits in tasks involving basic language components (e.g., words, sentences) would predict that the working memory demands associated with processing discourse level language would be even more challenging for children with LI. This area has not been previously investigated from a working memory perspective in this population and is one focus of the present research.

**Oral Discourse Skills in Children with LI**

In contrast to research regarding language correlates of ADHD, which have focused on higher level aspects of language functioning, the extensive research regarding language deficits in children with SLI has addressed both basic and higher levels of language functioning (see Leonard, 1998 for review). As it is expected that children with SLI will have significant difficulty comprehending and producing discourse level language, relatively few studies have examined specific skills associated with comprehension at this level. Two studies, however, found interesting connections between inferential comprehension and
visual processing abilities that are relevant to the present study. Ellis Weismer (1985) found that Grade 2 children with SLI had difficulty making inferences from stories regardless of whether they were presented in a verbal or pictorial format. This finding was replicated by Bishop & Adams (1992), who found that 8-12 year old children with SLI had as much difficulty comprehending facts and inferences from stories presented as a picture sequence as in a verbal presentation. In Bishop's sample, facts were as difficult for the children to comprehend as inferences in her comprehension tasks. These findings were interpreted as evidence of underlying cognitive deficits affecting the higher level constructive processes associated with language comprehension.

Another study by Copmann & Griffith (1994) found that children with LI had more difficulty than normal children and children with LD in comprehending and recalling story events from narrative passages, but they had even greater difficulty comprehending information from expository passages. Considering the model of discourse processing described earlier (Frederiksen, 1990), it is not surprising that children whose deficits involve the basic components of language would be most challenged in listening tasks requiring processing of many novel propositions at once and simultaneously making inferences in order to comprehend both the main ideas and specific details within an expository passage.

There have been only a few studies of comprehension monitoring abilities in children with LI, possibly since comprehension monitoring is a metacognitive skill that is expected to be difficult for children with LI. Skarakis-Doyle & Mullin (1990) and Skarakis-Doyle et al. (1990) investigated non-verbal indicators of comprehension monitoring in a small number of young children with LI using brief instructions varying in degrees of ambiguity. Findings were that LI subjects and younger receptive age-matched subjects showed rudimentary
nonverbal signs that instructions were confusing, but were unable to identify the source of the ambiguity verbally or gesturally as well as with normal children.

In summary, the above brief review suggests that deficits in verbal working memory are associated with basic language deficits in children with LI, affecting skills such as non-word repetition, vocabulary acquisition, and sentence comprehension. Children with SLI also show deficits in higher level comprehension abilities such as inferencing, even when visual support is provided. Considering these factors in combination with the increased working memory demands of processing discourse, children with LI would be most challenged at this level. Non-verbal cognitive skills appear to vary in children with SLI however some evidence suggests that visual processing skills may be an important component of language processing (Ellis Weismer, 1985; Bishop et al., 1992). It is also noteworthy that visual processing has not yet been examined in this population from a working memory perspective.

1.4: Summary of Issues

In ADHD clinical practice and research, relatively little is known about receptive language skills or how discourse is processed in children with ADHD, despite evidence of frequent co-occurrence of LI with ADHD. Important questions arising from this overlap are whether children with ADHD+LI have a unique profile of language deficits compared with children with LI alone, or whether their language impairments are more or less severe than those of children with LI. The present study addresses the latter issue, employing a four group design to examine listening comprehension skills in children with ADHD and LI, both alone and in the combined condition.
One question arising from studies investigating discourse production skills of children with ADHD is whether they also have difficulty with discourse processing, particularly in listening situations where working memory demands are high. Evidence to date suggests that comprehension of narrative discourse is unimpaired in children with ADHD, however studies have not addressed comprehension of information presented in other genres, such as expository discourse. Given that many daily interactions involve spoken explanations, incomplete or erroneous comprehension might contribute to the inappropriate and off-topic responses that are characteristic of ADHD. Therefore, a main objective of this study was to determine whether children with ADHD and average basic language skills comprehend factual and inferential information as well as normal children in challenging listening situations that require higher levels of sustained attention and working memory, which are needed for processing expository discourse.

Comprehension monitoring is a second aspect of discourse processing examined in this study. Problems with organization and self-regulation of behaviour are characteristic of ADHD. Complex spoken information requires normal listeners to use monitoring strategies to optimize their comprehension and retention of information. Children with ADHD who are generally poor at self-monitoring would be expected to be less likely to pick up on ambiguities, errors, or recognize their own comprehension difficulties during listening. Children with both ADHD and LI might be doubly compromised in developing comprehension monitoring skills due to the combined effects of their basic language deficits and self-regulation deficits associated with ADHD.

Recent investigations of working memory abilities in children with SLI suggest that it plays a major role in language comprehension. Empirical evidence also implicates working
memory as an underlying deficit in ADHD, with the suggestion that both spatial and verbal aspects of working memory may be involved. Another objective of this study was therefore to determine whether both verbal and spatial working memory deficits are present in children with ADHD and LI, and whether they are associated with performance on listening comprehension tasks.

**Rationale for Focus on Expository Discourse in this Study**

Expository discourse involves the language of explanation and instruction. Children are expected to process many explanations on a daily basis at home and at school, many of which involve processing both explicit and implicit meanings that are critical for task completion. Expository discourse is more formal and decontextualized in style than narratives or conversations, and has been considered to have greater associated processing demands (Coppman & Griffith, 1994; Westby, 1991). The present study undertook to investigate listening comprehension for expository discourse, as this genre appears to require higher levels of sustained attention, working memory, and cognitive effort during processing compared with other types of discourse. It was considered that the working memory and self-regulation deficits associated with ADHD might affect comprehension of more implicit meanings in explanations. In addition, comprehension of expository discourse has not been investigated previously in children with ADHD, despite its frequency of usage in daily communication.

The present study was motivated by the following research questions arising from the above issues:

1. Do children with LI (i.e., LI, ADHD+LI) have more difficulty comprehending discourse level language than children without LI (i.e., ADHD, normal children)?
2. Do children with ADHD+LI show more difficulty comprehending spoken expository discourse than children with LI alone? This question addresses whether there are additive effects of the two disorders that further compromise language performance in the combined group.

3. Do children with ADHD and average basic language skills comprehend spoken expository discourse as well as normally achieving children?

4. Do children with ADHD monitor their own listening comprehension as well as normal children?

5. Do children with ADHD and LI have deficits in verbal and spatial working memory compared with normally achieving children?

6. If so, are these aspects of working memory related to listening comprehension ability?

Specific Hypotheses

Listening Comprehension for Facts and Inferences

1. a) The ADHD+LI and LI groups are predicted to be poorer than the ADHD and Normal groups in answering factual and inferential comprehension questions from expository passages, due to the presence of deficits in basic language skills.

b) The ADHD+LI group is predicted to show poorer performance on passage comprehension questions than children with LI alone due to additive effects of deficits associated with ADHD and LI.

2. Given previous findings of adequate recall of factual details in narratives in children with ADHD (Tannock et al., 1993), it is predicted that the ADHD (no LI) group will
comprehend facts in expository passages as well as normal children.

3. The ADHD group is predicted to be poorer than the Normal group in comprehending less explicit information from spoken expository passages, specifically, in answering passage comprehension questions that require the ability to make inferences.

**Comprehension Monitoring**

1. a) ADHD+LI and LI groups are predicted to have significant difficulty with error detection, since basic level language deficits in these groups will be a disadvantage in a task that requires simultaneous comprehension and monitoring.

   b) The ADHD+LI group is predicted to perform more poorly on error detection tasks than the LI group due to additive effects of deficits associated with ADHD and LI.

2. The ADHD (no LI) group is predicted to show poorer ability to detect errors in expository passages than the normal group, given their characteristic difficulty with monitoring and self-regulation.

**Verbal and Spatial Working Memory**

1. a) The ADHD+LI and LI groups are predicted to show poorer verbal span and verbal working memory abilities than the ADHD and normal groups, due to the presence of basic language deficits.

   b) The ADHD+LI and LI groups are predicted to show significantly poorer spatial span and spatial working memory abilities compared with the ADHD and normal groups.
c) The ADHD+LI group is predicted to show poorer verbal and spatial span and working memory abilities compared with children with LI alone, due to additive deficits associated with ADHD and LI.

2. a) The ADHD group is predicted to show verbal memory spans that are comparable to those of the Normal group, but poorer verbal working memory abilities, given recent findings by Karatekin & Asarnow (1998) and Mariani & Barkley (1997).

b) The ADHD group is predicted to show poorer spatial span and spatial working memory skills than the normal group, given recent findings by Karatekin & Asarnow (1998) and Kempton et al., (1999).
Chapter 2  Method

2.1 Participants

Participants in the study were a community sample of 77 boys aged 9 -12 years. ADHD participants were recruited primarily through one pediatrician serving a large rural geographic region in Southwestern Ontario. Participants with Language Impairments (LI) and normal achievement (Normal group) were recruited through a public school system located within the same area. The researcher was not informed as to the identities of potential participants referred through both sources, and was contacted only by parents who were interested in having their child participate in the study.

Recruiting Procedures

ADHD and ADHD+LI Participants

The pediatrician’s office staff scanned a database of boys in the target age range who had been diagnosed with attention, behaviour, and/or learning difficulties, and generated a list of potential participants for the ADHD and ADHD+LI groups. This database comprised children referred from several sources, including family physicians, children’s service agencies, and public schools, and represented cases with a range of socioeconomic levels and severity levels of presenting concerns. An information package from the researcher including a cover letter from the pediatrician introducing the study was then mailed to parents for their consideration. Those parents interested in having their child participate were asked to contact the researcher directly. From this point, the researcher was the sole contact for the families for purposes of obtaining parent consent forms and parent/teacher questionnaires, arranging for and carrying out
the testing, and providing parent feedback. During the summer months permission was obtained to test children in local medical offices and mental health agency offices.

LI and Normal Control Participants

Administrative consent was obtained from a public school board for permission to recruit potential participants for the Language Impairment and Normal Control groups through contacts with principals, teachers, and educational consultants. Permission was also granted to carry out testing in school facilities during school time. School staff were asked to consider children with a reported history of learning difficulties and/or those awaiting language assessment, which were used as indicators of possible language impairment. A similar process of contacting parents was employed as with the ADHD children’s parents. Principals or special education teachers contacted parents of potential LI participants to describe the study and the testing the child would receive, and to determine whether they wished to receive an information package for further consideration. Parents then contacted the researcher directly or returned consent forms to the school if they agreed to their child’s participation in the study. For the Normal Control participants, parents of teacher-nominated students in Grades 4-6 were initially contacted by the classroom teacher and sent information packages if they were willing to consider their child’s participation as a Normal Control. Parents then returned consents and questionnaires to the school.

2.2 Measures

Three sets of measures were employed in this study. 1) Initial classification measures for ADHD and LI were used to assign participants to one of the four groups described above. 2) A second set of measures was administered for sample description purposes,
including a health and developmental history questionnaire, and tests of non-verbal cognitive ability and skills related to reading. 3) The dependent measures comprised:

a) listening comprehension measures and measures of memory span and working memory. All measures were individually administered to participants. Parent and teacher rating scales and developmental history questionnaires were completed prior to testing each child. A summary of the above measures is presented in Table 2.1.

Classification Measures

ADHD Classification

Conners Rating Scales -Revised (Parent and Teacher Long Forms).

The Conners Rating Scales - Revised (CRS-R) (1997) is a revision of the original Conners Rating Scales (1982; 1990), which were a series of behaviour rating scales developed for clinical assessment of attention and behaviour problems in children. The revised version integrated the earlier versions and re-standardized the scales for purposes of clinical assessment of Attention Deficit Hyperactivity Disorder (ADHD) and common comorbid disorders. The CRS-R is standardized on a large normative database and provides separate sets of norms for males and females. Psychometrically, the CRS- reports evidence for adequate internal reliability of index scores and discriminative validity for ADHD and non-ADHD groups. The CRS-R consists of short and long forms of parent and teacher questionnaires that employ a Likert-type rating of aspects of a child’s typical behaviour and task performance at home and at school. In addition to assessing the symptoms of Inattention and Hyperactivity/Impulsivity, the items also address learning issues and both externalizing (conduct problems, aggression) and internalizing (anxiety, depression) factors. Raw scores yield norm-referenced index scores (T-scores) in specific domains, which are
used to develop a profile of symptom severity for diagnostic purposes. The CRS-R also contains specific items that are coded for meeting DSM-IV diagnostic criteria for ADHD, yielding a 9-point DSM-IV subscale score along dimensions of Hyperactivity/Impulsivity and Inattention.

Four index scores were used to classify children in the ADHD groups. These were the Parent and Teacher T-scores for the ADHD Index, Inattention, Hyperactivity/Impulsivity, the DSM-IV Index, and the DSM-IV subscale scores from parent and teacher ratings for the dimensions of Hyperactivity/Impulsivity and Inattention. The ADHD index score is considered the most reliable score to support a clinical diagnosis of ADHD. It was also considered important to review scores in the Inattention and Hyperactive/Impulsive dimension for purposes of determining the composition of the ADHD groups with respect to DSM-IV subtypes. If criteria for this study were met in both parent and teacher reports within this cluster of T-scores and DSM-IV subscale scores, the child was classified in one of the ADHD groups. Criteria for group classification is described in detail in the section: Group Classification Procedures.

**Language Impairment Classification**

*Peabody Picture Vocabulary Test-III (PPVT-III)*

The *Peabody Picture Vocabulary Test-III* (Third Edition) (PPVT-III) (Dunn & Dunn, 1997) is the third edition of the earlier PPVT and PPVT-R by the same authors, which are norm-referenced measures of receptive vocabulary that have been widely used in clinical, educational, and research settings. The current edition was standardized on a stratified sample of 2,725 examinees, and reports high correlations with other verbal ability measures (e.g., the Verbal Scale of the WISC-III). The test specifically assesses recognition
of spoken vocabulary by asking the child to select one of four pictures to match a spoken word. Test items are grouped in sets of 12.

**Scoring** Basal and ceiling criteria are defined, and after a ceiling of 8 errors within one set is reached, testing is stopped and the child’s raw score is converted to a standard score.

*Expressive Vocabulary Test*

The *Expressive Vocabulary Test (EVT)* (Williams, 1997) is a norm-referenced measure of expressive vocabulary and word retrieval ability. The EVT was standardized on the same population as the PPVT-III, which provides a basis for interpreting variations in receptive and expressive vocabulary test performance, and can give an impression of the individual’s overall level of vocabulary development. This measure can also be used to quantitatively and qualitatively assess specific performance difficulties involving expressive vocabulary. For example, a significant discrepancy between the EVT score and PPVT-III score may suggest the presence of word retrieval difficulties. The EVT reliability analyses indicate a high degree of internal consistency, with split-half reliabilities ranging from .83 - .97. Test-retest reliability coefficients range from .77 - .90 indicating good test stability. Test administration for the 9-12 year age range involves presentation of a picture and a stimulus word describing the picture which is spoken by the examiner. The child is asked to think of a synonym for the stimulus word, and responses are scored correct, incorrect, or are prompted with specific cues if the child’s initial response is close to the target response. Prompts can be provided if the child’s first response matches one of the items on the prompt list. If the prompt results in a correct response the child receives a full score for the item.
Scoring: Basal and ceiling criteria are defined, and after a ceiling of 5 consecutive errors or no responses has been reached, testing is stopped and the child’s raw score is converted to a standard score.

Clinical Evaluation of Language Fundamentals - 3 (Third Edition) (CELF-3)

The Clinical Evaluation of Language Fundamentals-3 (Semel et al., 1995) is the second revision of the original CELF (1985) which was designed as a “clinical tool for the identification, diagnosis, and follow-up evaluation of language skill deficits” in children aged 6 to young adults aged 21. The CELF-3 is a norm-referenced battery of language tasks designed to assess basic skills in language content (semantic knowledge) and form (morphosyntactic knowledge) in listening and speaking modalities. Within the complete battery of 9 subtests, two sets of three core subtests yield separate composite standard scores for receptive and expressive language ability, which can be combined to yield a Total Language Score.

The CELF-3 is widely used in school and clinic settings for identification of language impairment. Recent reviews conclude that it is a useful measure of general language ability as part of a comprehensive language assessment, when interpreted by an experienced speech/language pathologist (Gillam, 1998; MacDonald, 1998). Tests of statistical validity reported by the test authors show strong correlations (.70 - .75) between the CELF-3’s composite Receptive Language, Expressive Language, and Total Language scores and Verbal Scale and Full Scale scores from the WISC-III, suggesting concurrent validity with another widely used test of verbal ability and intellectual ability. With regard to reliability testing, some concerns have been raised regarding internal consistency of individual subtest scores (Gillam, 1998; MacDonald, 1998), however internal reliability of
composite Receptive and Expressive Language scores appears to be adequate (.86-.94 for ages levels 6 - 14 years). As the composite scores were the main scores relied upon for LI classification in the present study, potential problems associated with interpreting individual subtest performance were avoided. Furthermore, the use of these measures together with two other well-standardized language measures (the PPVT-III and EVT) increased confidence in the accuracy of LI classifications.

Three receptive language subtest scores are used to derive the composite Receptive Language Score. Specific skills assessed include following multistep directions containing conceptual terms (Concepts and Directions), making word associations (Word Classes), and solving verbal reasoning problems (Semantic Relationships). Three expressive language subtest scores are used for the composite Expressive Language Score, and assess skills in repeating sentences verbatim (Recalling Sentences), making up sentences with a given word (Formulating Sentences), and manipulating sentence constituents to produce various types of sentence patterns (Sentence Assembly).

In the present study, criteria for classification in the LI group specified evidence of both receptive and expressive language deficits, and the composite Receptive and Expressive Language Scores were used as separate measures of these aspects of language functioning. The Total Language Score was not used for classification purposes as it reflected combined receptive and expressive language performance, and did not provide a sensitive enough indication of the relative degree of receptive and expressive language performance differences in each child. The Listening to Paragraphs subtest, which is a supplementary subtest from the CELF-3 was also administered but was not used for classification purposes, as it is not included in subtest scores that are used to calculate the composite
Receptive Language Score. This task was included in the test protocol because it is a standardized listening comprehension task for narrative passages, and was intended as a point of comparison with children’s comprehension performance on the experimental comprehension task in this study involving expository passages.

**Scoring** Standard test administration specifies starting points for each subtest based on age. After a ceiling is reached of 5 consecutive errors or no responses on each subtest, testing is stopped. Raw scores are converted to standard scores which can be graphed to produce a profile of relative strengths and weaknesses in subtest performance. The 3 receptive and 3 expressive subtest scores are then each combined to yield composite Receptive and Expressive Language scores.

**Group Classification Procedures**

The ADHD measures and standardized language measures (described above) were used to classify 103 potential participants referred for the study into four groups according to the two factors, ADHD and LI, as follows: ADHD (no LI), ADHD+LI, LI, and normal controls. 77 children met criteria for inclusion in the three clinical groups and the normal control group. Children were not included in the study if they had sensori-neural hearing loss, significant motor disorders, emotional/behavioural disorders, developmental delay, pervasive developmental disorder, or if English was a second language in their home.

**ADHD Classification**

Symptoms of ADHD in children with a previous diagnosis were verified using the *Conners Rating Scales -Revised* (CRS-R) (Parent and Teacher Long Forms). Children were classified in the ADHD groups if their CRS-R results showed elevated T-scores (>60) on the ADHD, Inattention, Hyperactive/Impulsive, or DSM index scores and 6+ symptoms on one
of the two DSM-IV subscales (i.e. Inattention, Hyperactivity/Impulsivity) on either the parent or teacher reports. It should be mentioned that several children with previous diagnoses of ADHD were not included in the study as they did not meet the above criteria. In a few cases, children referred through the school system met criteria for ADHD classification and were included in the ADHD groups following review of scores with a senior research supervisor. Following testing, recommendations were made through the parent feedback process for clinical follow-up regarding the child’s ratings on the CRS-R, through a qualified clinician (i.e., Pediatrician, Child Psychologist, Child Psychiatrist).

LI Classification

Four standardized language measures were used in the classification of LI (described in detail in the following section), which assessed basic skills in receptive and expressive vocabulary, grammar, and syntax. Participants were classified in the LI groups if their standard scores on these measures were at least 1.5 standard deviation (SD) below the mean for age on 1 measure, or at least 1 SD below the mean for age on 2 measures, and if they showed evidence of deficits in both receptive and expressive aspects of language functioning.

Children classified as ADHD (no LI) met criteria for ADHD but not LI. Children classified as ADHD+LI met criteria for both conditions. Children classified as LI met the LI criteria but showed no evidence of ADHD.

Normal Control Group

Classroom teachers for Grades 4-6 in two public elementary schools (Grades K-8) were asked to refer children showing average achievement in all subject areas in their grade level. Normal group participants were recruited in the spring of the academic year, and
therefore their teachers were by this point familiar enough with their achievement and
behaviour to make appropriate recommendations. Teachers were discouraged from referring
children showing advanced academic skills or those who had been identified as gifted
learners, but rather to focus on children who were achieving consistently at Level 3 in each
subject area according to the Ontario Curriculum. At this level, children are considered to be
meeting grade level achievement standards.

Descriptive Measures

Considering the high incidence of Reading Disability (RD) associated with both
ADHD and LI (Shaywitz et al., 1994; Pennington et al., 1993; Catts, 1993) and evidence of
nonverbal cognitive deficits in the SLI population, standardized measures of word decoding
and non-verbal cognitive ability were included in the test protocol.

Word Attack subtest from the *Woodcock Reading Mastery Test-Revised* (WRMT-R)

The Word Attack subtest of the WRMT-R (Woodcock, 1987) evaluates basic
decoding skill in oral reading of pseudowords. The inability to decode pseudowords is
considered a sensitive indicator of reading disability. Accurate decoding of these items
requires the ability to apply knowledge of phoneme-grapheme correspondences for "words"
that could not have been previously learned and memorized. The child is asked to read sets
of non-words aloud (e.g., "plip, straced"), and responses are recorded phonetically. Item
sets gradually increase in difficulty. The test has adequate reliability values (.89-.94) for
children age-appropriate for Grade 5.

Scoring  Ceiling is reached when the child makes 6 consecutive errors ending with the last
items in a set. The raw score is then converted to a standard score.

Block Design subtest from the *Wechsler Intelligence Scales for Children-III*
The Block Design subtest from the (WISC-III) (Wechsler, 1991) was used as a measure of non-verbal cognitive ability. It is noted that in many studies involving clinical samples, an

Table 2.1 Summary of Measures

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Memory span and working memory measures

- span - verbal or spatial information held in short term memory for repetition (numbers/ FW forwards)
- working memory - verbal or spatial information held in short term memory while performing another cognitive task (repeating numbers/ FW in backwards order)

Numbers subtest* from *Children’s Memory Scale*

- verbal span/ working memory
- # of items correct for numbers forward and backward (raw scores)

Finger Windows subtest* from *Wide Range Assessment of Memory and Learning*

- spatial span/ working memory
- # of items correct for Finger Windows forward and backward (raw scores)

*Both the Numbers subtest and the Finger Windows subtest provide standard scores, however the standard scores from the Numbers subtest are for total performance on forward and backward repetition of numbers. The Finger Windows standard scores are for the forward administration only for this task - as backward administration of each of these tasks was used as the working memory measures, raw scores were used in the analyses.

An abbreviated set of verbal and performance subtests from the WISC-III is used as an estimate of intellectual functioning. In the present study, the Block Design subtest was selected as a reasonable estimate of non-verbal cognitive ability as it has the strongest correlation ($r = .68$) with Performance IQ of the WISC-III performance subtests. Furthermore, as both the PPVT-III and CELF-3 have strong concurrent validity with the WISC-III, it was not considered necessary to add other WISC-III verbal subtests to the protocol to rule out the presence of severe cognitive deficits in this sample. The Block Design task requires the child to use red and white blocks to reproduce an abstract design which is presented to them in picture form. Following a training procedure, the child is presented with designs increasing in complexity, and the time taken to reproduce the design is recorded.
Scoring  After a ceiling of 2 consecutive failures to reproduce the designs within a
specified time period, testing is stopped and raw scores are converted to standard scores. In
the present study, Canadian normative data (1993) were used in converting raw scores to
standard scores.

**Dependent Measures**

**Listening Comprehension Measures**

1. Expository Passage Comprehension Task

The ability to comprehend facts and inferences in spoken passages was assessed in
an original experimental comprehension task consisting of passages written in the expository
genre. The format of the task was modeled on standard reading comprehension tests
designed to assess reading comprehension at the passage level. Assessment of
comprehension ability in both listening and reading modalities must take into account the
influence of background knowledge (Kintsch, 1988). As this variable cannot be completely
controlled, the passages were designed to reflect a balance between topic familiarity and
novelty of content so as to provide an estimate of the children’s ability to process relatively
novel information. Therefore, an attempt was made to set the difficulty level of the passages
between the two extremes of information that was highly familiar to children and for which
they would have well-developed schema, and information that was so obscure that it would
pose too much difficulty for normal listeners. The passages were written on topics children
might encounter at school, for example, in science or geography lessons. Each passage was
about a familiar topic, but presented some novel information judged to be outside most
children’s knowledge and experience.
One trial and four experimental passages were developed with these factors in mind. Construction of each passage was similar in terms of content, organization, style, and linguistic characteristics. Each passage explained a procedure related to the topic, for example how something is made. The first sentence of each passage was a question introducing the topic. For example, one passage described how cranberries are grown (Cranberry passage: “Have you ever seen a cranberry farm?”), and another passage explained the steps for a dessert recipe (Baked Alaska passage: Have you ever had a fancy dessert called Baked Alaska?). Following the introduction, the passages continued with descriptive and procedural details and a concluding statement. Cohesive adverbs such as “first”, “next”, and “finally” were used consistently to signal the steps of the procedure. Comprehension questions for both facts and inferences were then extracted from the novel information in the passages. Factual recall questions were taken from information directly stated in the passages. Inferential questions referred to agents, locations, or cause-effect relationships implied in the passages, but which were not stated explicitly. Details regarding administration of the passages, the text of the passages, and scoring guidelines are presented in Appendix B.

Each passage was controlled for length with regard to number of words and sentences. Vocabulary difficulty was kept constant at the Grade 5-6 level using the Dale-Chall readability index (Chall, 1995) to rate vocabulary level of reading passages. This level was considered to be an appropriate level of difficulty for listening purposes for the age range of the sample. Passage characteristics are summarized in Appendix D. The trial and experimental passages were audiotaped by an adult Canadian female speaker whose first language is English, using a consistent style and rate of oral presentation.
Piloting of the comprehension passages was carried out in two ways. Wording, content, and consistency of each passage and set of comprehension questions was initially reviewed by a group of graduate student raters. Minor changes were made to wording of passages and questions based on group feedback. The passages were then piloted with 20 children in the target age range for the study. The pilot data indicated that normally achieving children had more correct responses to questions than children with language, learning, and/or attention difficulties. A summary of data from the piloting of the measures is presented in Appendix E.

Administration of the passage comprehension task took an average of 20-25 minutes, beginning with task instructions and presentation of the trial passage and questions, and followed by the 4 experimental passages and comprehension questions. After each test passage, which required about 2 minutes of sustained attention, the child answered 16 comprehension questions comprising three different types: 6 questions regarding facts, 5 questions designed to generate inferences in a direct Question-Answer format, and 5 questions designed to generate inferences in a True/False question format. As it was considered that the inference questions would be difficult for children with LI, two types of inference questions were used to assure better overall reliability of responses.

Of the 10 inference questions for each passage, the first 5 (Question-Answer format), involved a “Wh” question (i.e., who, what, where, etc.), designed to elicit a direct answer. The second 5 questions (True/False format) stated an assertion about some information in the passage, and the child was asked to judge if it was True or False. In order to reduce the effect of guessing, the child was asked to explain his reasoning for correct T/F responses to ensure that the inference had been understood. As many of the children in the 3 clinical
groups had expressive language difficulties, prompts such as "tell me more", or "what do you mean by that?" were used to promote an optimal response. It was expected that the True/False questions would be easier for the LI children, since they were less demanding of verbal retrieval skills. Moreover, the children received some degree of scaffolding to prompt their explanations which were scored only for content. Guidelines for the types and degree of prompting were set at the beginning of the study, and were applied consistently during testing. Responses to the questions were transcribed verbatim during the testing, and also tape recorded for scoring reliability checks and later analyses.

Scoring A scoring guide was developed for each set of comprehension questions, with content criteria specified for full, partial, and no credit responses. Scoring was based on evaluating the content of the child's response with respect to expression of ideas or information indicating that the facts and inferences had been understood. Correct responses to factual and inferential questions received a score of 2, for a total factual comprehension score of 12, a direct inference score of 10, and a T/F inference score of 10 for each passage. Partial scores were given if the response contained parts of the content criteria specified for the question; various responses that could be assigned a partial score were outlined in the scoring guide. Over the set of 4 passages, scores for facts, direct inferences, and T/F inferences were combined to yield a total score for each type of question out a possible score of 48 for facts, 40 for direct inferences, and 40 for True/False inferences. The scoring guide is presented in Appendix B.

2. Comprehension Monitoring Measures

The second aspect of listening comprehension investigated in this study was comprehension monitoring ability. A novel comprehension monitoring task was modelled
on the error detection paradigm (Markman, 1979; Markman & Gorin, 1981; Walczyk & Hall, 1989a; 1989b) which has been used in previous research on comprehension monitoring in listening and reading. Detection of an error in meaning is considered one way to assess “on-line” monitoring abilities, as the child must report what does not make sense relative to what they have already understood in the passage. This task required the ability to sustain attention and monitor one’s own comprehension in order to make these judgments.

One potential problem in using the error detection paradigm to compare a normal group with clinical groups is evidence of variation in normal children’s ability to detect errors in spoken passages. Walczyk & Hall (1989a) studied error detection skills in two groups of normally achieving children classified as exhibiting primarily a reflective versus impulsive cognitive style, as indexed by the Matching Familiar Figures Test. Children with a more reflective cognitive style were expected to perform better than the impulsive children in detecting factual inconsistencies in short narrative passages. Findings showed that although their error detection skills were superior to those of the impulsive group, they did not detect all the errors in the passages. These findings with normally achieving children suggest that error detection is a challenging task, therefore in clinical research, passage difficulty must be calibrated to facilitate optimal performance of the normal control group in order to provide a valid point of reference for comparison of the clinical groups.

Several procedural refinements to the initial error detection tasks (Markman, 1979) appeared in the literature over the 1980’s after its first introduction as a method of assessing comprehension monitoring. In normal children, error detection was reported to be improved when children were instructed regarding a clear purpose and criteria to evaluate what they
listened to (Markman & Gorin, 1981; Winograd & Johnston, 1982), and when they had some familiarity with the topic (Walczyk & Hall, 1989b).

With the above considerations in mind, two separate error detection tasks were developed, each comprising one trial and 4 experimental passages. The two tasks differed in style of construction and content, the first involving sequenced instructions and the second a set of descriptive/explanatory paragraphs. To control for processing demands associated with passage length, both sets of error detection passages were shorter than the earlier set of comprehension passages. Passage characteristics are presented in Appendix D.

The Listening to Instructions task comprised a trial passage plus 4 test passages describing the steps of familiar routines of daily living (e.g., changing a lightbulb, planting a garden). Three of the four passages contained instructions out of correct sequence which were located in the middle of each passage. The sequence error was within 1-2 sentences from the correct step. Vocabulary used in the passages was at the Grade 4 level, according to the Dale-Chall index. Each passage required about 1 minute of listening time. Successful comprehension of the error was intended to cause the listener to realize that the goal of the activity could not be achieved if the instructions were followed as stated.

The Listening to Descriptions task comprised a trial passage plus 4 test passages, and were similar in style, vocabulary level (Dale-Chall level Grade 5-6), and content to the earlier set of comprehension passages, in that they were about familiar topics but presented some novel information to the listener. The goal in this task was for the child to detect factual inconsistencies that would cause some critical information to not make sense. For example, in the “Jellyfish” passage it was initially stated that jellyfish have no bones, followed a few sentences later with another statement that their skeletons are curved in
shape. Three of the four passages contained factual inconsistencies. Again, the error proposition was within 1-2 sentences of the proposition it refuted and was located midway though the passage. Each passage required about 80 seconds of listening time.

The child was instructed that sometimes people make mistakes in what they say and do not make sense, and that his help was needed in judging from a child’s point of view whether some instructions and descriptions on tape made sense or not. The child was told that some of the passages might have some mistakes in them, and others might be correct. The child’s job was to listen carefully and “act like a judge” to decide if there were errors in 1) the order of instructions and 2) inconsistencies in facts presented in descriptions (i.e., whether the information made sense or not). The child then listened to the audiotape of the trial passage.

If the child did not detect the error in the trial passage after 2 presentations, he was prompted with a demonstration and explanation of the error to ensure that he understood the goal of the task. Once it was clear to the examiner that the child understood the task, the 4 test passages were then presented. After listening to each passage, the child was asked if everything made sense. If he reported a problem with the passage and identified and explained an error, the response was accepted and recorded, whether it was the target error or not. The child was then asked if there were any other mistakes in the passage before moving on, followed by presentation of the next passage.

Consistent with the methodology of Walcyk & Hall (1989a), if the passage was judged to make sense on the first hearing, the child was encouraged to listen again “just to make sure”, and was reminded that the passages might have mistakes or they might be correct. This prompt was provided consistently for both error and foil passages in an
attempt to avoid cueing the child that he had missed an error on the first hearing (i.e., using comments such as: “let's listen again just to make sure”, and “everybody gets to listen 2 times”). In some cases in the clinical groups the child's response was off-task and the child was redirected to listen to the passage again after being reminded of what type of error to listen for. For example, if the child challenged a fact presented in the passage rather than identifying steps out of order, he was redirected to the task purpose (“tell me if everything was in the right order”) and given a score of 0 for the first presentation.

The error detection passages required less listening time than the earlier comprehension passages, each task requiring between 10-15 minutes for administration of the trial and four experimental passages versus 20-25 minutes for the earlier comprehension passages. The Listening to Instructions passages each required 1 minute of sustained listening, and the Listening to Descriptions passages (listening to descriptions) required approximately 2 minutes of listening time. The Listening to Instructions task was easier than the Listening to Descriptions task with regard to vocabulary level (Dale-Chall level Grade 4) and with also with regard to syntax used; as the Listening to Instructions passages were written in a natural instructive style, each key proposition in the passages was more readily formulated using simple commands. The two error detection tasks were separated by other tasks that were not listening oriented (e.g., the Finger Windows task).

In three instances of children in the ADHD group, the foil passages were not played twice when the child stated that there was nothing wrong with the passage and he did not want to listen to it again. In these cases, it was felt that the child's best overall task performance would be obtained by moving on to the next passages. As these children were less amenable to hearing the passages a second time, extra prompting and encouragement
were reserved for the passages where a second presentation might make a difference in their scores. Since there were no cases in the sample where a correct response for the foil passages (i.e., "no mistakes") was changed on the second presentation, it was considered unlikely that the above cases would affect scores for the ADHD group as a whole. Consequently, these children received a score of 1, which was the maximum possible score for the foil passages.

**Scoring.** Full credit for error detection for each passage was based on whether the child correctly identified the error and could explain it. As with the first set of passages, the child’s response was evaluated on content versus quality of formulation of the explanation. Correct identification of the target error plus supporting explanation received a score of 2 for passages containing errors. Correct judgment of no error for the foil passages received a score of 1.

Separate scores were recorded for each presentation of the passages, yielding a total possible score of 7 for each of the first and second presentations of the set of passages for Task 1 and Task 2 (i.e., 2X3 (error passages) + 1 (foil passage) = 7 for each presentation).

In a few instances (<5), partial scores of 1 were given in situations where the child identified the location of the error, but was unable to explain it after the second listening (e.g., “it was something about being too hot or something” re: “changing a lightbulb”). Also, 2 children identified plausible inconsistencies in the passages, such as in the “penguins” passage, that the passage stated that penguins dive down deep for food but live on fish near the surface of the water. These children received partial credit (i.e., a score of 1) for these responses as they demonstrated some monitoring of the information in the passages but missed the target errors.
Memory span and working memory measures

Verbal and spatial memory abilities were assessed using two tasks with parallel formats and task demands with regard to remembering and reproducing increasingly longer sequences of information, both forwards and backwards.

1. Verbal Span and Verbal Working Memory Measure

The Numbers subtest from the *Children’s Memory Scale* (Cohen, 1997) is a standardized task used to assess verbal span and verbal working memory which requires approximately 5-6 minutes of administration time. Reported reliability values vary from .71-.78 for the forward measure and from .69-.80 for the backward measure. The span measure involves asking the child to repeat sets of numbers in the same order as the examiner, which gradually increase in length from 2 to 9 numbers per set. Each number set is presented at a consistent rate of one number per second. After the ceiling item is reached on the numbers forward repetition task, the working memory task is presented, where the child is asked to repeat different number sets in backward order from the examiner’s presentation. Each task proceeds with number sets increasing in length until the child reaches a ceiling of two consecutive errors in a set of items of the same length.

Scoring. In standard scoring procedures, the numbers forward raw score is added to the numbers backward raw score, and then converted to an overall standard score for verbal memory ability. For the purposes of this study, both standard and raw scores were tabulated in order to allow for separate analyses of span and working memory aspects of each child’s performance.

2. Spatial Span and Spatial Working Memory Measure

The Finger Windows subtest from the *Wide Range Assessment of Memory and Learning* (Adams & Sheslow, 1990) was used to assess memory span and working memory ability for spatial information. In this task the child watches as the examiner inserts the end of a pencil through a series of randomly spaced holes (described as “windows”) on an 8X11 inch card at a rate of approximately one hole per second. The child is then asked to show the
examiner the same holes in the same order by putting his finger through each hole. The holes are numbered on the side of the card facing the examiner so that the child’s response can be recorded as a number sequence and for ease of administration of each stimulus item. The spatial sequences gradually increase in length over the task from sets of 2 to sets of 6 holes. Standardized administration of the Finger Windows subtest specifies forward administration of the spatial sequences, and therefore is primarily a measure of the child’s spatial memory span. For the purposes of this study, a backward administration of the Finger Windows subtest was also used to gain a measure of the child’s working memory abilities for spatial information, which would complement the format of the verbal measure, involving both forward and backward repetition of number sequences. The same stimulus items as for the forward administration were used in the backward administration. The forward and backward tasks were not administered consecutively.

**Scoring**  In standard scoring procedures, the raw score for the forward administration is converted to a standard score once a ceiling of three consecutive errors has been reached. In this study, scores were recorded both as raw scores for the forward and backward administration, as well as the standard scores for the forward administration.

**Testing Procedures**

Following receipt of consent forms for participation in the study, parents and teachers were asked to complete the Long Forms of the *Conners Rating Scales - Revised*. For children taking medication for ADHD, parents and teachers were asked to complete the behaviour ratings focusing on the child’s behaviour while off-medication. In a few cases in which the child’s current teacher was not familiar with behaviour off-medication, this was indicated on the questionnaire, and where possible assistance was obtained from former teacher (e.g., from the previous grade) who was familiar with behaviour off-medication. Parents also completed a developmental/health history questionnaire.

All ADHD medications were withheld for 36-48 hours prior to testing. Each
participant completed a 4 hour test protocol, administered over 2 sessions, and was tested individually by the researcher who is a registered speech-language pathologist. All measures were administered individually by the researcher in either a school or clinic setting in a quiet room with minimal distraction. Arrangements were made with the participants’ teachers and parents regarding an appropriate schedule and advance notice for the testing to take place so important or preferred activities would not be missed. Each child was familiarized with the study and its objectives by the parent at home, and acknowledged their assent verbally before testing was started. Following completion of the second set of tests, each child received a certificate of appreciation for their participation in the study.

Parents of children with ADHD who were taking psychostimulant medication to manage their ADHD symptoms were asked to withhold the child’s medication for 36-48 hours prior to each testing session. Withholding medication is a standard practice in research with children with ADHD, as the effect of psychostimulant medications on cognitive and language performance skills is not yet completely understood. Also, given the variations in type and dosage of medications used in medical management of ADHD, being on medication during testing would be a potentially serious confounding variable in interpreting test performance. Concerns regarding disruption to medication routines and potential problems associated with being off-medication at school were carefully addressed with each parent and teacher. As medical management often involves children with ADHD taking medication only on school days, many of the current participants were typically off-medication over the weekends. Testing was therefore arranged for a Monday morning or Monday afternoon and medication was restarted immediately after the testing session ended (i.e., the child would take his noon hour dose after the morning session, or would resume a once daily dose on the Tuesday morning).

In cases where the child was on daily medication, parents were asked if they would be willing to withhold medication for the two days prior to each testing day in order for the no-medication criterion to be met. All parents cooperated with this request when scheduling
of testing was carefully planned to reduce the potential for stress and behavioural difficulties at home and in the classroom due to being off-medication. For example, in one case, permission was obtained to assess the child at his school on a Sunday afternoon after medication had been withheld from the Friday morning dose, given the parent’s concern over the child arriving at school unmedicated on a Monday morning.

The test protocol was administered in the same order for each participant. At the beginning of session 1, a standard pure tone hearing screening was administered for the frequencies 500, 1000, 2000, and 4000 Hz. at 20 decibels using a portable audiometer. Responses at 25 decibels for 500 Hz. were considered a pass given the effects of ambient noise on reliable screening at this frequency. Standardized tests were administered in their entirety according to procedures specified in the test manuals. In a few instances where the child’s language abilities had been assessed at school within the previous six months, permission was received to obtain test scores from the clinician involved on the CELF-3, PPVT-III, or EVT if these tests had been used, and these measures were not re-administered. These children then completed the remainder of the measures in the test protocol.

Tests completed in Session 1 were: audiometric screening, the PPVT-III, the CELF-3 (including the Listening to Paragraphs subtest), the Numbers subtest, the Word Attack subtest (WRMT-R), and the EVT. Session 1 required approximately two hours for participants to complete all tests, and a 10-15 minute break was provided after the first hour.

Tests completed in Session 2 were: the expository passage comprehension task, the Block Design task, the two error detection tasks, and the forwards and backwards Finger Windows tasks. As the listening comprehension tasks required maintenance of motivation and concentration, they were alternated with non-verbal visual tasks such as the Block Design and Finger Windows in order to obtain the child’s optimal performance. The order of presentation of the two error detection tasks was varied over the sample. The forward and
backward administrations of the Finger Windows task were also separated by other tasks in order to promote concentration and avoid fatigue.

**Parent Feedback Procedure**

Parents were contacted individually by telephone with descriptive feedback and interpretation of their child's performance on the standardized language measures (PPVT-III, EVT, CELF-3), the Word Attack subtest, and the listening comprehension measures (passage comprehension, error detection tasks). In some cases, feedback was provided in a face-to-face meeting at school or home, with teachers and school administrators present at the parents’ request. Feedback was also summarized in individual written reports provided to each parent, with recommendations regarding follow-up assessments and/or program support and teaching modifications to address identified weaknesses in language abilities. Parent feedback was contextualized primarily in terms of the impact of language processing difficulties on school performance (e.g., following instructional language in the classroom), comprehension of language in social situations, and the potential effect of listening comprehension difficulties on progress in reading comprehension, especially when combined with weak word attack and phonemic awareness skills.

In several instances, criteria for ADHD classification were met on the parent and teacher responses to the *Conners Rating Scales-Revised* in children referred primarily with concerns over language abilities. These cases were each reviewed with senior research supervisors to decide an appropriate strategy for parent feedback, which was independent of whether or not the child was classified in the ADHD group for the research study. Parents were then informed of the findings by the researcher and suggestions were made for how they could follow up if they chose to do so with further assessment by a clinician qualified to address questions related to a diagnosis of ADHD. *Conners Rating Scales - Revised* profiles of T-scores were provided to physicians or clinical psychologists at the parent’s request and with signed permission.
Procedures re: Reliability of Scoring

The majority of tasks in the test protocol were objective measures and yielded numeric data following counts of responses, which were checked by the researcher when results were summarized for data entry. Prior to data analysis, scores for the responses to factual and inferential questions in the passage comprehension task were rechecked by the researcher using the participants’ taped responses and transcriptions to check for any inconsistencies in scoring. As scoring for this task involved interpretation of whether responses met specific content criteria, an inter-rater scoring reliability check was carried out for 20% of the sample (16 participants). Following familiarization of a second rater with the scoring guide, two examples from the sample were demonstrated and scored jointly. Then, equal numbers of participants were selected at random from each of the four groups. Responses were re-scored on new score sheets using the taped responses to questions from all four test passages for each participant selected. Each set of questions was scored independently by the researcher and the second rater. Comparison of independent scores for the 16 cases that were reviewed showed 93.2% agreement for scoring of factual responses, 90.9% agreement for scoring of direct inference responses, and 88% agreement for scoring of True/False responses. Any discrepancies were resolved prior to data analysis through discussion with reference to the scoring guide.

Scoring reliability for the error detection passages was of less concern as the children’s responses were easily scorable on line, however they were also rechecked prior to data analysis, primarily in the area of ensuring that criteria for partial credit for responses had been consistently applied across the entire sample.
Statistical Analyses

A series of MANOVA's were used for analysis of the ADHD and LI classification measures and the descriptive measures, with the Bonferroni test used for post hoc analysis of group differences. As this study was designed to address specific hypotheses related to predicted effects of ADHD and LI on listening comprehension performance, ANOVA's with 3 planned orthogonal (independent) contrasts (Rosenthal & Rosnow, 1985) which addressed all specific hypotheses were applied to the dependent measures of listening comprehension and working memory. These were numbered for all analyses: 1. LI versus non-LI groups, 2. ADHD+LI versus LI groups, and 3. ADHD versus the Normal group. Dependent measures were also analyzed with the descriptive measures of reading ability and nonverbal cognitive ability as covariates. Following these procedures, a hierarchical multiple regression analysis was conducted to determine predictive effects of the working memory variables on listening comprehension performance. Analyses were performed using SPSS version 10.0 for Windows. The alpha level for all analyses was set, a priori, at $p<.05$. 
Chapter 3 Results

3.1 Sample Characteristics

Sample characteristics of interest to this investigation were age, maternal education level, history of early otitis media with effusion (OME), comorbidity of behavioural disorders, presence of Reading Disability (RD), and composition of the ADHD groups with respect to ADHD subtypes. A summary of these data appears in Table 3.1.

No significant age differences were found across the four groups (F(3,73,) = .59, p<.621). Maternal education level was used as a measure of SES, and was reported in family and developmental history questionnaires completed by parents prior to the child’s assessment. These data are reported as the proportion (in percentages) of mothers from each group who had completed high school. The ADHD+LI group had the lowest percentage of mothers with high school education (77.7%), with 84.2% and 90.4% of mothers of children in the LI and ADHD groups respectively having completed high school. All mothers of children in the Normal group reported having completed high school.

Parents were also asked to report whether their child had experienced early chronic ear infections (i.e., more than several that were severe enough to require medical attention) between the ages of birth and 4 years. Early chronic otitis media with effusion (OME) has been linked to both developmental language and behavioural difficulties in young children (Friel-Patti & Finitzo., 1990), and was considered relevant background information to gather for the clinical groups being studied. Similar percentages of parents reported histories of recurring ear infections in the two ADHD groups, with the most chronic ear infections reported in the Normal group, and the least reported for the LI group.
T-scores from the *Conners Rating Scales-Revised* were reviewed for indications of other conditions such as Oppositional Defiant Disorder and Anxiety Disorder which are frequently reported to co-occur with ADHD (AACAP, 1997). Percentages of children from each group whose scores on the ODD and Anxiety indices were >65 were noted. Approximately half of the ADHD group and about one third of the ADHD+LI group had T-scores >65 from parent and teacher ratings of behaviour. About one quarter of the LI group was also rated highly for oppositional behaviour. These proportions reflect different children receiving these ratings across parent and teacher reports, however a small group received high T-scores on ODD and Anxiety indices from both parents and teachers. For ODD ratings, 5 ADHD children, 3 ADHD+LI children, and 2 LI children had scores >65 on both parent and teacher ratings. For Anxiety ratings, 2 ADHD children, 2 ADHD+LI children, and 1 LI child had scores > 65 on both parent and teacher ratings. It is also noteworthy that 41% of the combined clinical groups (i.e., ADHD, ADHD+LI, LI) had elevated anxiety ratings from their teachers. These data are presented in detail in Appendix A.

Children whose scores on the Word Attack subtest (WRMT-R) were below 85 (i.e., 1 SD below the mean) were classified as RD for the purposes of this investigation, with the recognition that a formal diagnosis of RD would require them to meet additional criteria. According to this cutoff score, more than half of children in each of the clinical groups were classified as RD.
#### Table 3.1: Sample Characteristics: Age, SES, History of Chronic OME, Presence of ODD and Anxiety (Parent - P and Teacher - T), RD, ADHD Subtypes

<table>
<thead>
<tr>
<th>Group</th>
<th>ADHD</th>
<th>ADHD+LI</th>
<th>LI</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>21</td>
<td>18</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Age* (M: SD)</td>
<td>10.9(1.2)</td>
<td>11.1(1.2)</td>
<td>10.6(1.1)</td>
<td>10.8 (.8)</td>
</tr>
<tr>
<td>High school education</td>
<td>90.4%</td>
<td>77.7%</td>
<td>84.2%</td>
<td>100%</td>
</tr>
<tr>
<td>History of OME**</td>
<td>27%</td>
<td>27.8%</td>
<td>15.8%</td>
<td>36.8%</td>
</tr>
<tr>
<td>ODD -P</td>
<td>52.3%</td>
<td>38.9%</td>
<td>26.3%</td>
<td>0%</td>
</tr>
<tr>
<td>ODD - T</td>
<td>52.3%</td>
<td>33.3%</td>
<td>21%</td>
<td>0%</td>
</tr>
<tr>
<td>Anxiety - P</td>
<td>19%</td>
<td>11.1%</td>
<td>15.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Anxiety - T</td>
<td>42.8%</td>
<td>33.3%</td>
<td>42.1%</td>
<td>0%</td>
</tr>
<tr>
<td>RD</td>
<td>61.9%</td>
<td>72%</td>
<td>72%</td>
<td>0%</td>
</tr>
<tr>
<td>Inattentive Subtype</td>
<td>19%</td>
<td>22.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined Subtype</td>
<td>81%</td>
<td>77.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* F=.59, p<.62
** percentage of sample with reported history of recurring OME between 0-4 years

With regard to ADHD subtypes within the DSM-IV classification system, 19% of the ADHD group and 22.2% of the ADHD+LI group showed evidence of primarily inattentive symptoms, and 81% of the ADHD group and 77.8% of the ADHD+LI group showed evidence of both inattentive and hyperactive/impulsive symptoms. There were no children exhibiting symptoms of the primarily Hyperactive/Impulsive subtype.
76% of the ADHD group and 64% of the ADHD+LI group were referred through the pediatric caseload as described previously, and the Conners Rating Scales -Revised were used to confirm that each child continued to meet criteria for ADHD through current parent and teacher ratings. It should be mentioned that not all of the pediatrician-referred children with ADHD were included in the study due to inconsistent ratings between home and school. The remaining cases in the ADHD groups arose from a group of children referred for the study by school principals who were considered as potential LI participants due to concerns over significant learning problems. However, a number of these children met the predetermined ADHD classification criteria and were therefore considered for the ADHD groups. Each previously undiagnosed case was reviewed with a senior clinical researcher as part of the classification decisions. Parents of these children were provided with feedback that further investigation of ADHD by a qualified clinician would be appropriate based on their responses and those of their child’s teacher on the CSR-R.

With regard to information regarding medical management of the children in the ADHD groups, 16 of the 25 previously diagnosed cases were taking stimulant medication for ADHD symptoms. In the remaining children, parents had acknowledged the diagnosis but had elected not to have their child take medication. No other long-acting medications were being taken, nor were any children taking medications for anxiety or depression. One child had been treated with Clonidine during the school year, but had been off this medication during the summer when testing took place.
3.2 Analyses of Classification and Descriptive Measures

Review of Frequency Distributions

Bimodal distributions were observed for T-scores from the four indices of the Conners Behaviour Scales-Revised that were used for classification in the ADHD groups (Inattention; Hyperactivity/Impulsivity/ADHD index; DSM index). The scores of the normal group fell well below clinically significant levels, and the scores of the three clinical groups were distributed normally over the borderline normal and clinical range. Standard scores from the standardized language measures (i.e., Peabody Picture Vocabulary Test-III, Expressive Vocabulary Test (EVT), and Clinical Evaluation of Language Fundamentals-3 (CELF-3)) were normally distributed, as were distributions of the descriptive measures (i.e., Block Design subtest from the WISC-III, Word Attack subtest from the WRMT-R).

ADHD Measure

MANOVA's were used to determine group differences on parent and teacher ratings of ADHD symptoms from the Conners Rating Scales - Revised (CRS-R). Results indicated that the two ADHD groups (ADHD, ADHD+LI) did not differ on T-scores on the ADHD, Inattention, Hyperactive/Impulsive, and DSM indices on the CRS-R. Therefore, differences in severity of ADHD symptoms were not potential factors in group comparisons of performance on the dependent measures. Review of T-scores of children in the LI group revealed slight overlap with the ADHD groups in the borderline normal range with respect to teacher ratings of Inattention, and post hoc comparisons using the Bonferroni test revealed that these were significantly higher than those of the Normal group (p<.0001). Means and standard deviations for Conners Rating Scales-R scores are
presented in Table 3.2. It should be noted in this table that higher scores reflect more severe behaviour symptoms.

### Table 3.2: Classification Measures for ADHD: Group Means and Standard Deviations of Parent (P) and Teacher (T) Scores from The Conners Rating Scales-R

<table>
<thead>
<tr>
<th>Conners Rating Scales-Revised</th>
<th>Group 1 ADHD (n=21)</th>
<th>Group 2 ADHD/LI (n=18)</th>
<th>Group 3 LI (n=19)</th>
<th>Group 4 Normal (n=19)</th>
<th>F Values (df=3,73)</th>
<th>Post hoc comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>T- scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P ADHD</td>
<td>M = 70.7 (7.9)</td>
<td>M = 68.4 (8.7)</td>
<td>M = 58.0 (9.2)</td>
<td>M = 46.1 (4.0)</td>
<td>41.2***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>P Inattention</td>
<td>70.0 (7.9)</td>
<td>69.8 (7.2)</td>
<td>57.6 (9.2)</td>
<td>46.0 (4.9)</td>
<td>45.3***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>P Hyperactive/Impulsive</td>
<td>68.2 (15.1)</td>
<td>68.3 (14.4)</td>
<td>53.6 (9.6)</td>
<td>47.6 (5.0)</td>
<td>15.1***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>P DSM</td>
<td>71.1 (10.0)</td>
<td>70.6 (10.5)</td>
<td>56.5 (8.1)</td>
<td>46.5 (4.5)</td>
<td>36.5***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>T ADHD</td>
<td>72.9 (8.1)</td>
<td>72.55 (9.1)</td>
<td>56.7 (5.9)</td>
<td>42.9 (3.6)</td>
<td>81.0***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>T Inattention</td>
<td>70.6 (5.9)</td>
<td>73.2 (4.9)</td>
<td>63.3 (5.3)</td>
<td>43.0 (3.8)</td>
<td>137.6***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>T Hyperactive/Impulsive</td>
<td>67.4 (13.0)</td>
<td>63.5 (14.2)</td>
<td>49.5 (7.5)</td>
<td>44.6 (4.8)</td>
<td>20.7***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
<tr>
<td>T DSM</td>
<td>70.95 (7.1)</td>
<td>70.9 (8.3)</td>
<td>57.7 (4.9)</td>
<td>43.3 (3.9)</td>
<td>83.6***</td>
<td>1,2&gt;3&gt;4</td>
</tr>
</tbody>
</table>

***p<.001

**Language Measures**

Using MANOVA with Bonferroni post hoc tests, analysis of group differences on the standardized language measures indicated that the two LI groups (ADHD+LI, LI) showed comparable language scores. The ADHD and Normal groups showed equivalent scores on the receptive vocabulary test (PPVT-III) and on the Formulated Sentences subtest of the CELF-3, however on the remainder of the standardized language tasks, while
the mean scores of the ADHD group were within the normal range, (i.e. within 1 SD from the mean) they were significantly poorer than those of the Normal group.

The Listening to Paragraphs subtest was not used in classification decisions as it is not used to compute composite scores on the CELF-3. However, it was used in this investigation for comparative purposes as a standardized listening comprehension passage for narratives. Results on this task showed a different pattern of performance than for the other language tasks, in that there were no differences in mean scores for the Normal, ADHD, and ADHD+LI groups, and only the LI group showed significantly poorer performance. Group means and standard deviations for performance on the standardized language measures are presented in Table 3.3.

**Descriptive Measures**

Results of MANOVA’s and post hoc tests showed significant group differences on measures of nonverbal cognitive ability (i.e., the Block design subtest from the WISC-III) and reading ability (i.e., the Word Attack subtest from the WRMT-R). Scores of the ADHD+LI group and the Normal group were not significantly different on the Block Design subtest, although this may have been a reflection of a very high score attained by one child in the ADHD+LI group. The ADHD and LI groups showed significantly poorer scores on the Block Design task compared with the Normal group, with scores tending to lie in the low average range of ability. With respect to reading ability, all three clinical groups (ADHD, ADHD+LI, LI) showed significantly poorer scores on the Word Attack subtest compared with the Normal group. Group means and standard deviations pertaining to these measures are presented in Table 3.4.
Table 3.3: Classification Measures for Language Impairment: Group Means and Standard Deviations of Scores on the PPVT-III, EVT, and CELF-3

<table>
<thead>
<tr>
<th>Standard Language Scores</th>
<th>Group 1 ADHD n=21</th>
<th>Group 2 ADHD/LI n=18</th>
<th>Group 3 LI n=19</th>
<th>Group 4 Normal n=19</th>
<th>F Value (df = 3, 73)</th>
<th>Post-hoc comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>PPVT-III</td>
<td>102.2 (9.9)</td>
<td>90.7 (5.0)</td>
<td>90.7 (10.5)</td>
<td>109.8 (10.4)</td>
<td>19.0***</td>
<td>4,1 &gt; 2,3</td>
</tr>
<tr>
<td>EVT</td>
<td>92.7 (7.3)</td>
<td>82.2 (8.5)</td>
<td>85.7 (10.0)</td>
<td>101.3 (7.5)</td>
<td>18.9***</td>
<td>4 &gt; 1,2,3</td>
</tr>
<tr>
<td>CELF-3 composites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLS</td>
<td>94.0 (10.5)</td>
<td>77.8 (9.1)</td>
<td>79.0 (6.1)</td>
<td>107.8 (8.7)</td>
<td>48.9***</td>
<td>4 &gt; 1 &gt; 2,3</td>
</tr>
<tr>
<td>ELS</td>
<td>94.0 (7.5)</td>
<td>76.2 (12.9)</td>
<td>76.5 (14.0)</td>
<td>108.2 (6.1)</td>
<td>40.0***</td>
<td>4 &gt; 1 &gt; 2,3</td>
</tr>
<tr>
<td>CELF-3 subtests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concepts &amp; Directions</td>
<td>9.4</td>
<td>(1.9)</td>
<td>6.2</td>
<td>(1.9)</td>
<td>6.3</td>
<td>(1.1)</td>
</tr>
<tr>
<td>Word Classes</td>
<td>8.8</td>
<td>(2.3)</td>
<td>5.9</td>
<td>(2.4)</td>
<td>5.9</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Semantic Relationships</td>
<td>8.8</td>
<td>(2.5)</td>
<td>7.5</td>
<td>(1.5)</td>
<td>7.6</td>
<td>(1.6)</td>
</tr>
<tr>
<td>Formulated Sentences</td>
<td>10.1</td>
<td>(1.7)</td>
<td>6.1</td>
<td>(2.3)</td>
<td>6.9</td>
<td>(2.2)</td>
</tr>
<tr>
<td>Recalling Sentences</td>
<td>9.1</td>
<td>(2.1)</td>
<td>6.3</td>
<td>(2.7)</td>
<td>6.5</td>
<td>(2.3)</td>
</tr>
<tr>
<td>Sentence Assembly</td>
<td>7.9</td>
<td>(1.8)</td>
<td>6.7</td>
<td>(2.1)</td>
<td>6.2</td>
<td>(1.9)</td>
</tr>
<tr>
<td>Listening to Paragraphs</td>
<td>9.8</td>
<td>(2.3)</td>
<td>9.2</td>
<td>(2.5)</td>
<td>8.6</td>
<td>(2.9)</td>
</tr>
</tbody>
</table>

***p<.001

RLS Receptive Language Score
ELS Expressive Language Score
Table 3.4: Descriptive Measures: Group Means and Standard Deviations of Scores on Block Design (WISC-III) and Word Attack (WRMT-R) subtests

<table>
<thead>
<tr>
<th>Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>F Value (df = 1,73)</th>
<th>Post hoc comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADHD n=21</td>
<td>ADHD+LI n=18</td>
<td>LI n=19</td>
<td>Normal n=19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>4.5**</td>
<td>4,2 &gt; 1,3</td>
</tr>
<tr>
<td>Word Attack</td>
<td>8.8 (2.2)</td>
<td>9.4 (3.1)</td>
<td>8.5 (2.1)</td>
<td>11.1 (1.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRMT-R</td>
<td>185.1 (14.9)</td>
<td>82.6 (12.1)</td>
<td>80.2 (14.5)</td>
<td>106.9 (7.1)</td>
<td>18.1***</td>
<td>4 &gt; 3,2,1</td>
</tr>
</tbody>
</table>

**p<.01  ***p<.001

3.3 Analyses of Dependent Measures

Review of Frequency Distributions

Scores for comprehension of facts, inferences, true/false inferences, error detection, verbal span and verbal working memory, and spatial span and spatial working memory were normally distributed over the entire sample. Neither ceiling nor floor effects were in evidence in raw scores or group means of the comprehension measures and the memory span and working memory measures.

Listening Comprehension Measures

1. Expository Passage Comprehension Tasks

Analysis for Passage effect

In order to determine the presence of a potential passage effect, a repeated measures analysis was carried out with Passage (4) as the repeated measure and Group as the between-subjects variable. There were no significant Group x Passage interactions for the scores pertaining to comprehension of facts (F(3,71)= .825, p<.59) and true/false
inferences (F(3,71)=.893, p<.53). For scores on the direct inference questions, a Group x Passage interaction was marginally significant (F(3,71)=1.89, p<.055). Following these findings, group means for inference scores for each passage were plotted to determine which passage was causing the interaction. It was determined that the second passage ("Baked Alaska") appeared to be more difficult than the other passages, however since it appeared to be equally difficult for all groups, this minor effect was not considered to pose a problem for the overall analyses of the comprehension measures.

Analysis of Expository Passage Comprehension Scores

Univariate tests with planned orthogonal comparisons were conducted on the mean scores for comprehension questions regarding facts, inferences, and true/false inferences from the four test passages. Planned contrasts were for: 1. the LI and non-LI groups, 2. the ADHD+LI and LI groups, and 3. the ADHD and the Normal group. Group mean scores and standard deviations from the passage comprehension measure and results of these analyses appear in Table 3.5. There were significant differences in comprehension scores between the non-LI (ADHD, Normal) and LI (ADHD+LI, LI) groups, but no differences on the three passage comprehension scores between the ADHD+LI and LI groups. Regarding the third planned contrast, as hypothesized, the ADHD group’s scores for facts were comparable to those of the Normal group, however significant differences were found for scores on both types of inference questions.
Table 3.5: Group Means and Standard Deviations of Total Scores for Comprehension of Facts, Inferences and True/False Inferences

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>F Value</th>
<th>planned contrasts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADHD n=21</td>
<td>ADHD+LI n=18</td>
<td>LI n=18</td>
<td>Normal n=19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>31.8 (7.6)</td>
<td>26.8 (5.6)</td>
<td>22.6 (9.8)</td>
<td>34.8 (5.3)</td>
<td>10.4***</td>
<td>*** ns ns</td>
</tr>
<tr>
<td>SD</td>
<td>5.0</td>
<td>3.4</td>
<td>6.8</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inferences (max. 40)</td>
<td>23.2 (5.0)</td>
<td>19.3 (5.8)</td>
<td>17.4 (6.9)</td>
<td>27.8 (4.0)</td>
<td>13.3***</td>
<td>*** ns **</td>
</tr>
<tr>
<td>M</td>
<td>21.7 (4.1)</td>
<td>20.4 (7.7)</td>
<td>31.2 (2.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>5.5</td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True/False</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inferences (max. 40)</td>
<td>26.1 (5.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>21.7 (4.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>4.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p<.02
*** p<.001
ns non-significant

2. Error Detection Tasks

Repeated measures analyses were conducted separately for the Listening to Instructions task and the Listening to Descriptions task, with Group as the between-subjects factor and Time (i.e., Time 1 and Time 2) as the within-subjects factor. Group performance was not averaged across the two error detection tasks because of the differences in content, length, vocabulary, and error type. However, comparison of differences in total mean scores for the first and second presentations of each task suggested that the Listening to Instructions task was more difficult for all of the clinical groups than Listening to Descriptions task. For the Listening to Instructions task, there were significant effects for Time (p<.0001) and Group (p<.0001), but no Group x Time interaction. For the Listening to Descriptions task, there were significant effects for Time
(p<.0001) and Group (p<.05), plus a significant Group x Time interaction (p<.0001).

Group means and standard deviations of scores on the error detection tasks are presented in Tables 3.6 and 3.7 below. Means represent summed scores over the four passages for the first and second presentations of each task, with a maximum score of 7 for each task.

Following these analyses, planned contrasts were conducted as for previous measures. As there was no Group x Time interaction for the Listening to Instructions task, mean scores for Time 1 and Time 2 were averaged for the planned contrasts analysis. For the Listening to Descriptions task, there were no significant differences in group means for Time 1, and so planned contrasts were conducted using group means for Time 2. For the Listening to Instructions task, the two LI groups (LI, ADHD+LI) were significantly poorer than the non-LI groups, however they did not differ from each other. The ADHD group was significantly poorer than the Normal group in detecting errors in sequenced instructions, but performed better than the two LI groups. Review of the group means for the Listening to Descriptions task (Table 3.7) indicated that the Normal group showed relatively greater improvement in their error detection scores after the second presentation compared with the other groups. Planned contrasts conducted using Time 2 mean scores indicated that the two LI groups were significantly poorer than the non-LI groups in detecting factual inconsistencies in expository passages, however again did not differ from each other. The ADHD group showed marginally poorer ability to detect these errors compared with the Normal group, although this difference only approached statistical significance (p<.06). These results are presented in Table 3.8.
### Table 3.6: Group Means and Standard Deviations for Total Scores on Listening to Instructions

<table>
<thead>
<tr>
<th></th>
<th>Group 1 ADHD n=21</th>
<th>Group 2 ADHD/LI n=18</th>
<th>Group 3 LI n=19</th>
<th>Group 4 Normal n=19</th>
<th>F-values</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>first hearing</td>
<td>3.3 (1.7)</td>
<td>2.3 (1.8)</td>
<td>2.4 (1.6)</td>
<td>4.6 (2.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>second hearing</td>
<td>4.1 (1.8)</td>
<td>2.9 (1.8)</td>
<td>3.3 (1.7)</td>
<td>5.7 (1.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***p<.001

### Table 3.7: Group Means and Standard Deviations for Total Scores on Listening to Descriptions

<table>
<thead>
<tr>
<th></th>
<th>Group 1 ADHD n=21</th>
<th>Group 2 ADHD/LI n=18</th>
<th>Group 3 LI n=19</th>
<th>Group 4 Normal n=19</th>
<th>F-values</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>first hearing</td>
<td>3.9 (2.2)</td>
<td>3.2 (1.9)</td>
<td>3.5 (2.1)</td>
<td>4.1 (1.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>second hearing</td>
<td>4.95 (1.7)</td>
<td>3.5 (1.8)</td>
<td>4.1 (2.1)</td>
<td>6.0 (1.2)</td>
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<td></td>
</tr>
</tbody>
</table>

*p<.05  ***p<.001
Table 3.8: Planned Contrasts for Error Detection Tasks

<table>
<thead>
<tr>
<th>Task 1 (Listening to Instructions)</th>
<th>Task 2 (Listening to Descriptions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a planned contrasts</td>
<td>b planned contrasts</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>error detection</td>
<td>trend</td>
</tr>
<tr>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>ns</td>
<td>***</td>
</tr>
<tr>
<td>**</td>
<td>ns</td>
</tr>
<tr>
<td>trend</td>
<td>(p&lt;.06)</td>
</tr>
</tbody>
</table>

a using averaged scores (Time 1 - Time 2)

b using scores from Time 2

** p<.01  *** p<.001 ns nonsignificant

Analysis for Effects of RD and Non-Verbal Cognitive Scores on Listening

Comprehension

A large proportion of children in the three clinical groups showed poor scores on the Word Attack subtest from the WMRT-R (i.e., standard scores < 85), and low average scores on the Block Design subtest (WISC-III). In order to determine potential effects of these skill deficits on listening comprehension, univariate analyses were conducted for each of the three listening comprehension scores (i.e., facts, inferences, true/false inference) using Word Attack and Block Design scores as covariates. Results showed no significant effect of reading scores on comprehension scores for facts or inferences (facts: F(1,71)=.49, p<.49); inferences: F(1,71)=.96, p<.33); true/false inferences: F(1,71)=.11, p<.74). Similarly, there was no effect of Block Design scores on the listening
comprehension scores (facts: (F(1,71)=.03, p<.87); inferences (F(1,71)=.02, p<.88); true/false inferences (F(1,71)=1.1, p<.30)).

Robustness of Listening Comprehension Measures

Review of the overall performance patterns of the normal and clinical groups on the listening comprehension measures suggested that the expository passages developed for the study were able to differentiate children with good versus poor listening comprehension skills. No floor or ceiling effects were observed for either the passage comprehension task or the error detection tasks. Normal children were able to attain scores reflecting approximately 72% accuracy for both factual and inferential questions, however children with LI were able to attain only about 50% accuracy on these items. For the error detection tasks, again, children with good monitoring skills could be differentiated from those with poor monitoring skills. Normal children were able to attain approximately 80% accuracy in their final error detection scores compared with children with LI who attained only 50% accuracy.

3. Verbal and spatial span and working memory measures

Univariate analyses with planned orthogonal contrasts were also conducted for scores on the verbal span, verbal working memory, spatial span, and spatial working memory measures, comparing 1. the LI and non-LI groups, 2. the ADHD+LI and LI groups, and 3. the ADHD and Normal groups. Results showed significant differences on all memory measures between the LI and non-LI groups, no differences between the ADHD+LI and LI group, and significant differences between the ADHD and the Normal group on the verbal working memory, spatial span, and spatial working memory measures. There was no difference between the ADHD group and the Normal group on the verbal
span measure (i.e., Numbers forward). Group means and standard deviations for performance on the verbal (Numbers subtest: *Children's Memory Scale*) and spatial (Finger Windows task: WRAML) span and working memory (WM) tasks are presented in Table 3.9.

Table 3.9: Group Means and Standard Deviations for Verbal and Spatial Span and Working Memory Measures

<table>
<thead>
<tr>
<th>Verbal and Spatial Span &amp; Working Memory</th>
<th>Group 1 ADHD n=21</th>
<th>Group 2 ADHD+LI n=18</th>
<th>Group 3 LI n=19</th>
<th>Group 4 Normal n=19</th>
<th>F values and Significance (df=3,73)</th>
<th>planned contrasts</th>
</tr>
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<tbody>
<tr>
<td>1. Verbal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers forward (span)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers forward</td>
<td>7.1 (1.3)</td>
<td>6.3 (1.9)</td>
<td>6.5 (1.5)</td>
<td>7.9 (1.4)</td>
<td>4.3***</td>
<td>*** ns ns</td>
</tr>
<tr>
<td>Numbers backward (WM)</td>
<td>4.0 (1.3)</td>
<td>3.4 (1.5)</td>
<td>3.8 (.9)</td>
<td>5.9 (1.1)</td>
<td>15.4***</td>
<td>*** ns ***</td>
</tr>
<tr>
<td>2. Spatial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger Windows forward (span)</td>
<td>12.8 (3.6)</td>
<td>12.7 (4.4)</td>
<td>13.2 (4.9)</td>
<td>17.5 (2.5)</td>
<td>6.4***</td>
<td>*** ns ***</td>
</tr>
<tr>
<td>Finger Windows backward (WM)</td>
<td>11.3 (3.3)</td>
<td>11.1 (3.0)</td>
<td>12.3 (3.3)</td>
<td>16.7 (2.4)</td>
<td>14.2***</td>
<td>*** ns ***</td>
</tr>
</tbody>
</table>

** p<.01  
*** p<.001  
ns non-significant
Correlations

A series of correlations were produced regarding the scores on the standardized language measures used for classification, and the two sets of dependent measures: a) memory span and working memory measures, and b) the listening comprehension measures. Table 3.10 displays Pearson Product Moment Correlation values for scores on the CELF-3 subtests and scores on the working memory measures. Correlations between scores from the main standardized language measures (PPVT-III, EVT, CELF-3) and the listening comprehension measures are displayed in Table 3.11. Correlations between scores on the listening comprehension measures and scores on the working memory measures appear in Table 3.12. As is evident in reviewing these tables, both verbal and spatial working memory measures showed significant moderate correlations with both the standardized language measures and the listening comprehension measures.
### Table 3.10: Zero Order Correlations between CELF-3 Subtests and Verbal and Spatial Span and Working Memory Measures

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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</thead>
<tbody>
<tr>
<td>1. Verbal Span</td>
<td>--</td>
<td>.55**</td>
<td>.25*</td>
<td>.36**</td>
<td>.38**</td>
<td>.32**</td>
<td>.45**</td>
<td>.41**</td>
<td>.56**</td>
<td>.37**</td>
</tr>
<tr>
<td>2. Verbal WM</td>
<td>--</td>
<td>.39**</td>
<td>.47**</td>
<td>.44**</td>
<td>.47**</td>
<td>.44**</td>
<td>.41**</td>
<td>.48**</td>
<td>.51**</td>
<td></td>
</tr>
<tr>
<td>3. Spatial Span</td>
<td>--</td>
<td>.70**</td>
<td>.28*</td>
<td>.40**</td>
<td>.45**</td>
<td>.18</td>
<td>.22</td>
<td>.29*</td>
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<td></td>
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<tr>
<td>4. Spatial WM</td>
<td>--</td>
<td>.42**</td>
<td>.37**</td>
<td>.53**</td>
<td>.30**</td>
<td>.32**</td>
<td>.45**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. Concepts/dir</td>
<td>--</td>
<td>.65**</td>
<td>.56**</td>
<td>.70**</td>
<td>.70**</td>
<td>.63**</td>
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<td>6. Word Classes</td>
<td>--</td>
<td>.57**</td>
<td>.63**</td>
<td>.59**</td>
<td>.63**</td>
<td></td>
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<td></td>
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<td>7. Semantic Rel</td>
<td>--</td>
<td>.52**</td>
<td>.57**</td>
<td>.64**</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>8. Form. Sent</td>
<td>--</td>
<td>.66**</td>
<td>.61**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Recall Sent</td>
<td>--</td>
<td>.59**</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10. Sent. Assembly</td>
<td></td>
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</table>

*p<.05  **p<.01
Table 3.11: Zero Order Correlations Between Standardized Language Scores and Listening Comprehension Scores

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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</thead>
<tbody>
<tr>
<td>1. PPVT-III</td>
<td>--</td>
<td>.66***</td>
<td>.54***</td>
<td>.58***</td>
<td>.59***</td>
<td>.50***</td>
<td>.56***</td>
<td>.41***</td>
<td>.47***</td>
</tr>
<tr>
<td>2. EVT</td>
<td>--</td>
<td>.65***</td>
<td>.66***</td>
<td>.52***</td>
<td>.46***</td>
<td>.59***</td>
<td>.33***</td>
<td>.47***</td>
<td></td>
</tr>
<tr>
<td>3. RLS</td>
<td>--</td>
<td>.82***</td>
<td>.55***</td>
<td>.57***</td>
<td>.62***</td>
<td>.36***</td>
<td>.48***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ELS</td>
<td>--</td>
<td>.50***</td>
<td>.46***</td>
<td>.54***</td>
<td>.33***</td>
<td>.44***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Facts</td>
<td>--</td>
<td>.72***</td>
<td>.82***</td>
<td>.42***</td>
<td>.51***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Inferences</td>
<td>--</td>
<td>.73***</td>
<td>.42***</td>
<td>.40***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. T/F Inferences</td>
<td>--</td>
<td>.54***</td>
<td>.53***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. ED - Task 1</td>
<td>--</td>
<td>.32***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. ED - Task 2</td>
<td>--</td>
<td>--</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

***p<.001

a PPVT-III - receptive vocabulary
b EVT - expressive vocabulary
c RLS - Receptive Language Score (composite) on CELF-3
d ELS - Expressive Language Score (composite) on CELF-3
Regression Analyses

Multiple regression analyses were used to determine the proportion of variance in the listening comprehension measures (i.e., scores for comprehension questions re: facts and inferences, scores on the error detection tasks) accounted for by specific predictor variables. Two fixed-order models were developed a priori predicting the incremental contributions of the variables of age, nonverbal cognitive ability (Block Design scores), language ability (language classification measures), behaviour ratings of ADHD, reading ability (Word attack scores), and memory span and working memory (verbal and spatial) to the variance on the listening comprehension scores for facts and inferences. Of particular
interest was the relative contributions of verbal and spatial working memory abilities to listening comprehension performance. For these analyses, parent and teacher T-scores on the ADHD index were combined to form a composite ADHD score. For language ability, Receptive Language Scores (RLS) and Expressive Language Scores (ELS) from the CELF-3 were combined to form a composite language score.

Results of the first regression analysis (Model 1) involving the above variables showed that the effects of age plus language ability together accounted for almost half of the variance in the three dependent language measures. However, the analysis failed to clarify relative predictive importance of any other variables entered after the language variable, even after varying orders of entry were attempted. In addition, problems associated with the possibility of multicollinearity had been suggested by the relatively strong correlations between the working memory scores and the standardized language scores that were used to derive the composite language variable. Furthermore, the number of independent variables in this model and the sample size suggested an increased possibility for generation of unstable predictions. Results of analyses for Model 1 are presented in Table 3.13, and illustrate the inability of the model to separate the effect of the composite language variable from the other variables of interest.
Table 3.13: Fixed Order Hierarchical Multiple Regression Analyses with Listening Comprehension Scores as Dependent Variables - Model 1

**Listening Comprehension - Facts**

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor Variables</th>
<th>B</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>age</td>
<td>3.3</td>
<td>.20***</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>Block Design</td>
<td>.7</td>
<td>.47***</td>
<td>.27</td>
</tr>
<tr>
<td>2.</td>
<td>composite language score</td>
<td>.3</td>
<td>.48</td>
<td>.01</td>
</tr>
<tr>
<td>3.</td>
<td>composite ADHD score</td>
<td>.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>verbal working memory</td>
<td>.17</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>spatial working memory</td>
<td>.12</td>
<td>.48</td>
<td>.002</td>
</tr>
</tbody>
</table>

*** p<.001

**Listening Comprehension - Inferences**

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor Variables</th>
<th>B</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>age</td>
<td>2.5</td>
<td>.186***</td>
<td>.186</td>
</tr>
<tr>
<td></td>
<td>Block Design</td>
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<td>.441***</td>
<td>.255</td>
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<td>2.</td>
<td>composite language score</td>
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<td>.445</td>
<td>.004</td>
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<td>composite ADHD score</td>
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<td>4.</td>
<td>verbal working memory</td>
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<tr>
<td></td>
<td>spatial working memory</td>
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<td>.448</td>
<td>.004</td>
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</table>

***p<.001
Table 3.13 cont’d

Listening Comprehension - True/False Inferences

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor Variables</th>
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<th>R</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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<td>.22</td>
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<td></td>
<td>Block Design</td>
<td>.9</td>
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<td>.29</td>
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<tr>
<td>2.</td>
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<td>.3</td>
<td>.52</td>
<td>.01</td>
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<tr>
<td>3.</td>
<td>composite ADHD score</td>
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<td></td>
</tr>
<tr>
<td>4.</td>
<td>verbal working memory</td>
<td>.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spatial working memory</td>
<td>.03</td>
<td>.52</td>
<td>.001</td>
</tr>
</tbody>
</table>

*** p<.001

A second model (Model 2) was developed that allowed a more specific focus on the working memory variables. Nonverbal cognitive ability was eliminated from the model as it was nonsignificant at any point of entry. The Word Attack measure was also eliminated as it had already been established in previous analyses that reading scores did not influence the language comprehension measures. The composite language variable was eliminated in consideration of the correlations between it and the working memory variables, and it was rationalized that, theoretically, if verbal working memory is an underlying factor in language ability, the language ability variable could be bypassed as an intermediate product of the effects of working memory. The second regression model (Model 2) was therefore a simplification of Model 1, comprising age, verbal working memory, spatial working memory, and the composite ADHD variable as predictor variables.
Results of the regression analysis for Model 2 showed that age plus verbal working memory accounted for about 25% of the variance in scores for comprehension of facts from the expository passages, however spatial working memory did not add any additional variance. Verbal working memory accounted for approximately 10% of the variance in performance on the Question-Answer and True/False inferential questions, with spatial working memory accounting for a small but additional 5% of the variance in these same scores. Comparison of results from Model 1 and Model 2 suggested that approximately 50% of the language-related variance indicated in Model 1 was accounted for by age plus verbal and spatial working memory combined. Results of analyses for Model 2 are presented in Table 3.14.

Table 3.14: Fixed Order Hierarchical Multiple Regression Analyses with Listening Comprehension Scores as Dependent Variables - Model 2

<table>
<thead>
<tr>
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<th>B</th>
<th>( R^2 )</th>
<th>( R^2 ) change</th>
</tr>
</thead>
<tbody>
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<td>.16***</td>
</tr>
<tr>
<td>2.</td>
<td>verbal working memory</td>
<td>1.2</td>
<td>.25**</td>
<td>.09***</td>
</tr>
<tr>
<td>3.</td>
<td>spatial working memory</td>
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<td>.270</td>
<td>.02</td>
</tr>
<tr>
<td>4.</td>
<td>ADHD composite</td>
<td>.04</td>
<td>.272</td>
<td>.002</td>
</tr>
</tbody>
</table>

**p<.01  ***p<.001
Table 3.14 cont'd:

Listening Comprehension - Inferences

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor Variables</th>
<th>B</th>
<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>age</td>
<td>2.4</td>
<td>.15***</td>
<td>.15***</td>
</tr>
<tr>
<td>2.</td>
<td>verbal working memory</td>
<td>1.4</td>
<td>.25**</td>
<td>.10**</td>
</tr>
<tr>
<td>3.</td>
<td>spatial working memory</td>
<td>.4</td>
<td>.30*</td>
<td>.05**</td>
</tr>
<tr>
<td>4.</td>
<td>ADHD composite</td>
<td>-.05</td>
<td>.31</td>
<td>.01</td>
</tr>
</tbody>
</table>

*p<.05  **p<.01  ***p<.001

Listening Comprehension - True /False Inferences

<table>
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<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.12**</td>
<td>.12**</td>
</tr>
<tr>
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<td>.23***</td>
<td>.11***</td>
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<td>.45</td>
<td>.28*</td>
<td>.05*</td>
</tr>
<tr>
<td>4.</td>
<td>ADHD composite</td>
<td>-.09</td>
<td>.30</td>
<td>.02</td>
</tr>
</tbody>
</table>

*p<.05  **p<.01  ***p<.001

On the error detection tasks, a different pattern of results emerged. Verbal working memory was again a significant predictor of listening comprehension for performance on the Listening to Instructions and the Listening to Descriptions tasks, with respect to monitoring comprehension via error detection, however the involvement of spatial working memory in performance of these tasks only approached significance (p<.06). A unique finding in the regression analyses was the significance of the composite ADHD variable as
a predictor of performance in detecting errors in sequenced instructions (Listening to Instructions), after the effects of age and working memory had been partialled out. This was the only one of the listening comprehension measures that was related to the behaviour ratings of parents and teachers. These results are presented in Table 3.15.

Table 3.15: Fixed Order Hierarchical Multiple Regression Analyses with Error Detection Scores (Task 1 & Task 2) as Dependent Variables

### Listening to Instructions

<table>
<thead>
<tr>
<th>Step</th>
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</tr>
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<tr>
<td>4.</td>
<td>ADHD composite</td>
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<td>.25*</td>
<td>.05*</td>
</tr>
</tbody>
</table>

*p<.05  **p<.01

### Listening to Descriptions

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<th>$R^2$</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
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<td>.02</td>
<td>.02</td>
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<td>verbal working memory</td>
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<td>.03</td>
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<tr>
<td>4.</td>
<td>ADHD composite</td>
<td>-.02</td>
<td>.21</td>
<td>.01</td>
</tr>
</tbody>
</table>

***p<.001
Chapter 4  Discussion

4.1 Overview of Results

The main purpose of this study was to examine discourse level listening comprehension and working memory skills in children with ADHD, LI, and ADHD+LI. Analysis of performance on passage comprehension and comprehension monitoring tasks using planned orthogonal contrasts showed that the two LI groups were the most impaired of the four groups in listening comprehension for facts and inferences in expository passages, and were also poorer in monitoring their own comprehension in error detection tasks. Contrary to expectations, children with ADHD+LI were not poorer in their comprehension skills than children with LI alone, nor were their scores on the language classification measures lower than those of the LI group. A third set of planned contrasts showed that while children with ADHD appeared to be able to comprehend factual information as well as normal children and could detect factual inconsistencies in brief spoken expository passages, they were significantly poorer at comprehending inferences and monitoring comprehension of sequenced instructions.

Analysis of performance on verbal and spatial memory tasks found that the two LI groups (ADHD+LI and LI) groups showed significantly poorer scores on the verbal span measure (repeating number sequences in forward order) compared with the non-LI groups. In contrast, all three clinical groups showed significantly poorer performance on the verbal working memory task (repeating number sequences in backward order) and both the spatial span and spatial working memory tasks compared with the Normal group. Furthermore, the clinical groups did not differ amongst themselves in performance on these measures. The relationship between working memory and listening comprehension was analyzed
using a hierarchical regression procedure which showed that verbal working memory accounted for roughly 9-11% of the variance in listening comprehension performance on the listening tasks used in this study, with spatial working memory accounting for a small but additional 5% of the variance on inference scores.

4.2 Experimental Listening Comprehension Tasks and Methodology

The four expository passages and questions used in the passage comprehension task were modeled on tasks used in many standardized tests of reading ability, as well in school exams and achievement tests. The passages appeared to be useful measures of comprehension of expository information for this age group of children, and were particularly sensitive to the language processing difficulties of children with LI (i.e., LI, ADHD+LI). There was no significant passage effect, nor were there ceiling or floor effects. Normally achieving children found the passages moderately challenging but were still able to attain high scores on the factual and inferential questions. Although not subjected to formal psychometric analyses of validity and reliability, the sensitivity of the passages to the processing difficulties of children with LI suggest that they may be valid measures for future studies of listening or reading comprehension.

The two error detection tasks (Listening to Instructions and Listening to Descriptions) also appeared to successfully differentiate children who could monitor comprehension well, and children who were poor at this skill. As with the passage comprehension tasks, these tasks were particularly difficult for children with LI (i.e., LI, ADHD+LI).

As with many research protocols assessing cognitive and language abilities in children, performance on tasks presented to children in one-to-one testing conditions may
not be accurate reflections of performance abilities or limitations in more naturally occurring contexts. For example, the error detection tasks involved a contrived situation where a planned error was presented and evaluated by the child. The child had to adjust to an external set of demands (i.e., task instructions from the researcher) to complete the task, which might involve different skills than would be used during naturally occurring situations where the child would rely on internal versus external criteria for monitoring (Dollahan, 1987). Another aspect of this issue relative to the normal group’s overall superior performance on the “directed” listening comprehension tasks used in this study is they were perhaps more flexible in their ability to adjust to external task demands (i.e., were more “directable”) than the children in the other groups.

With regard to task administration, it could be argued that prompting the child to listen to the passage a second time after he indicated that the passage made sense would bias the child’s second response toward more effort toward in finding the error or would be confusing to the child with respect to task demands. In the task administration used in this study, all children heard each passage twice if they stated it there were no errors on the first presentation (this was also true for the foil passages). If they committed themselves to a specific error, their responses were acknowledged and scored regardless of whether they were correct or not. If anything, the second presentation ensured that the child was more fully engaged in the task, and this was reflected by the improvement of scores in all groups after the second presentation of the passages.

4.3 Listening Comprehension for Expository Passages

The results of this study supported the hypothesis that children with LI would show the poorest performance on challenging listening comprehension tasks. The two LI groups’
scores on all the listening comprehension measures were consistently lower than those of the ADHD and Normal group. The hypothesis predicting additive effects of ADHD and LI in the combined group (ADHD+LI) was not supported by results on the language and listening comprehension measures. The ADHD+LI and LI groups did not appear to differ quantitatively with regard to scores on comprehension of facts and inferences from the expository listening passages. These findings suggest that presence of ADHD does not appear to have a worsening effect on listening comprehension performance in children with ADHD+LI compared with children with LI alone. Stated another way, although ADHD children were found to have subtle comprehension deficits compared with normally achieving children, once LI was added to their profile, there was no apparent impact on the degree of difficulty they showed on the comprehension tasks relative to that of children with a similar degree of LI but no ADHD.

Consistent with previous findings for narrative passages (Tannock et al., 1993; Purvis and Tannock, 1997), ADHD children in this study were able to comprehend and recall factual information from expository passages as well as normal children. However, this same group of children whose language abilities were average for their age demonstrated poorer comprehension of less explicit information. This difference was demonstrated in two types of inference questions (i.e., direct answer and True/False questions) suggesting that the ADHD children’s difficulty generating inferences was independent of task demands. A further consideration regarding these results is that given that there was no competing noise or distraction during administration of the passages, the data may represent these children’s optimal comprehension performance under ideal listening conditions. Children with ADHD and otherwise average language abilities may
have even poorer comprehension of inferential information in other settings such as classrooms, where factors such as background noise, interruptions, and visual distractions are not as well controlled.

Several factors were considered regarding a possible explanation for why generating inferences during listening would be specifically difficult for children with ADHD. One issue concerns whether their poorer scores on inference questions related to the length of the listening tasks used in this study. Although a specific measure of inferencing at the sentence level was not included in the dependent measures, scores from the Semantic Relationships subtest from the CELF-3 were reviewed to investigate this possibility, as it involves short reasoning problems requiring semantic inferences. Review of the ADHD children’s performance on this subtest in Table 3.3 showed that although their scores were within the average range for their age, they were significantly poorer than those of the Normal group. This comparison suggests that making inferences from spoken language is a particularly difficult task for children with ADHD, and appears to be independent of the length of information they are processing.

One may also question whether the ADHD group’s relatively lower scores on the standardized language measures (i.e., CELF-3) could account for their poorer performance on the inferencing questions from the listening passages, since making inferences is a higher level process in discourse comprehension. Considering that the ADHD+LI and LI groups’ performance on the comprehension tasks was expected to be limited by their basic language deficits, the ADHD group’s performance might also be limited to a lesser extent by their low average language skills, which might affect only higher levels of language processing functions (e.g., making inferences). This possibility might also explain why
facts were easier to process than inferences, since comprehension of facts (i.e., directly stated propositions) relies on basic semantic and syntactic abilities, and involves fewer high level processing demands according to models of discourse processing (Frederiksen et al., 1990). The ADHD group’s basic language abilities may have been well enough developed to comprehend the facts in the passages, but were not well enough developed to move beyond processing of basic propositions to making inferences from them.

Another factor accounting for the ADHD group’s inferencing problems could be the contribution of their working memory deficits to their low average scores on the CELF-3. Results of a study by Turkstra (1999) involving clinician ratings of the working memory load of individual subtests of the CELF-3 suggested that this battery of language tasks has high working memory demands on several subtests, which could confound interpretations of task performance. In this study, consistent moderate correlations were found between the verbal and spatial working memory measures and the CELF-3 subtests (Table 3.10). With regard to the ADHD group, this issue makes it difficult to clarify the potential effect of lower average language scores on listening comprehension, considering that the working memory deficits evident in these children may have prevented them from doing better on the CELF-3 language subtests.

Another possible factor accounting for ADHD children’s poorer performance in inferencing is that they may be less efficient than normal children at generating inferences “off-line” in retrieval tasks such as those used in this study. Even though the task administration was designed to facilitate optimal conditions for the children to respond, partial scores were given, and the scoring guidelines focused on the content of responses, the ADHD group showed poorer comprehension of the implied concepts in the passages.
Also, because measurement of comprehension depends on expressive language and retrieval skills to a large extent, skills which do not seem as well-developed in ADHD children, their performance might have been taxed by the response demands of the comprehension questions. Eliciting verbal responses to comprehension questions may also place additional demands on working memory resources needed to simultaneously recall information from the passage and plan and produce a verbal response. Even though the ADHD group’s performance on the Formulating Sentences subtest of the CELF-3 appeared to be one of their relative strengths compared with other subtests, the simultaneous processing and formulation demands of the comprehension questions may have exceeded their capacity to deal with the complex information in the passages.

4.4 Comprehension Monitoring

As predicted, both the ADHD+LI and LI groups performed at levels well below those of the ADHD and Normal groups in detecting errors in spoken expository passages, however as with the findings for the listening comprehension passages, the mean scores and standard deviations of these two groups were nearly identical. Therefore, the hypothesis that the ADHD+LI group would perform more poorly than the LI group on the error detection tasks was not supported by the data.

The findings of this study were in partial support of the hypothesis predicting poorer comprehension monitoring abilities in children with ADHD. Consistent with earlier findings of Walczyk & Hall (1989a), the error detection tasks appeared to be challenging for all groups including the Normal group, even though specific instructions were given regarding what to listen for, and the tasks were brief and quite motivating for the children. In reviewing the data analyses, the effects of the first and second presentations of the
passages and task type were two main factors that appeared to affect performance on the error detection tasks.

All four groups improved their error detection scores between the first and second presentations of the passages, but there were substantive differences between results for the Listening to Instructions and Listening to Descriptions tasks. In the Listening to Instructions task, all groups showed relatively similar degrees of improvement in their scores between the first and second presentation. However, in the Listening to Descriptions task, even though there were nonsignificant differences in total scores over the two presentations between the ADHD group and the Normal group, a Time x Group interaction indicated that the Normal group improved their scores more than the other groups after the second presentation. This finding provides additional evidence that comprehension monitoring is a difficult task for children with ADHD and LI.

There appeared to be a difference between the Listening to Instructions and Listening to Descriptions tasks in overall performance patterns and scores. Recall that the Listening to Instructions passages were shorter and easier linguistically than those of the Listening to Descriptions task. Despite this difference, the ADHD group’s mean scores in detecting errors in the order of instructions were significantly poorer than those of the Normal group even after being given two opportunities to listen to the passages. This apparent relative difficulty of the Listening to Instructions task could not be attributed to an order of presentation effect since the order of administration of the two tasks was varied equally throughout the sample.

The passages in the Listening to Descriptions task were slightly longer than those of the Listening to Descriptions task, and their content, style and vocabulary difficulty
were similar to the earlier expository passages, each explaining some novel information about familiar topics. The child had to identify two incompatible propositions for a correct score. Overall, the ADHD group attained higher average scores on this task than on the Listening to Instructions task, and although their mean score was slightly less than that of the Normal group after the second presentation, this difference just approached statistical significance. The relatively better performance of the ADHD group on the Listening to Descriptions task could be related to the earlier finding that processing and recalling facts do not seem to be problematic for children with ADHD. Also, the processing demands for detecting factual inconsistencies may be different than those required for detecting errors in sequences. Identification of errors in instructions may require attention to and maintenance of a complete sequence in working memory, whereas identification of factual errors in descriptions may require a smaller set of propositions to be maintained during processing.

One could argue that the ADHD group’s lower overall scores on basic language measures might account for their evidently weaker monitoring skills, however if this were true, their poorer performance would have been on the Listening to Descriptions passages which were longer and more difficult linguistically. Their weakest performance was on the Listening to Instructions task, which was the easier of the two error detection tasks with respect to length, sentence structures, topic familiarity, and vocabulary level, but which appeared to present greater challenge with respect to error type.

The critical skill needed to detect errors in the Listening to Instructions task was the ability to process sequential information (e.g., steps in changing a flat tire, planting a garden, etc.), which appeared to be challenging for all three clinical groups. A task analysis of the process involved in identifying steps out of sequence suggested that the child had to
create a mental representation of at least 3 steps from the text of the passage: the step that was out of order and the steps preceding and following it. For example, in the “changing a flat tire” passage, the child had to identify that it was not possible to take the wheel off the car without jacking it up first. This reasoning would involve considering the steps of taking the wheel off, jacking up the car (preceding step) and putting the spare tire on the car (following step), and holding them in working memory while comparing the order from the passage with pre-existing knowledge of the correct sequence. This process would require the processing functions of storage, maintenance, and manipulation of mental representations in working memory in order to make this comparison.

As with the earlier listening comprehension passages, verbal working memory was required in order to hold the instructions in mind as presented in the passage while considering whether there was a sequence error or not. It is speculated however that there might also be some degree of “visualizing” of the steps in order to identify the error, in a similar manner to the creation of visualized situation models referred to by Graesser et al (1994) as occurring naturally during reading of narratives. Visualization during listening applied to Listening to Instructions would involve spatial-sequential representations of the out of order steps being held in working memory while they were being compared with the correct steps that had been stored in long term memory in the form of a procedural script. However, firm support for this possibility was not evident from the regression analyses conducted for the error detection tasks, which showed that the predictive effect of spatial working memory scores on error detection scores only approached statistical significance.
4.5 Memory Span and Working Memory Abilities in Children with ADHD and LI

This study’s findings regarding memory span and working memory abilities in children with ADHD and LI were consistent with some previous investigations and not with others. It should be kept in mind that working memory is a broad cognitive construct that has been tied to several aspects of language development (Gathercole & Baddeley, 1990), reading ability (Swanson, 1999), and school achievement (Pickering et al. 1998). No studies have assessed working memory systematically in children with ADHD and LI, and ADHD studies that have focused on this area have not consistently ruled out presence of LI and RD in their research samples.

The present results showing the LI groups as being deficient in verbal memory span and verbal working memory are consistent with a number of previous studies of children with SLI (Kahmi et al., 1988; Ellis Weismer et al., 1999; Montgomery, 1995a; 1995b; 2000), in which these deficits were interpreted as evidence of reduced cognitive capacity underlying their language processing problems. Following from this view, the reduced verbal spans and working memory abilities of the two LI groups in the present study would explain their poor performance in tasks that required greater working memory capacity to match the demands of processing complex discourse (Just & Carpenter, 1992). The consistent finding that ADHD+LI and LI groups did not differ in degree of impairment on the listening tasks used in this study suggested that the combined effects of ADHD and LI are not additive in nature with respect to working memory performance.

In the present study, the ADHD group demonstrated similar performance to the Normal group on the verbal memory span task (repeating numbers in forward order), however was significantly poorer on the verbal working memory task (repeating numbers
in backward order). Other recent studies have examined memory span and working memory abilities in children with ADHD, however results to date have varied. Both Siegel & Ryan (1989a) and Karetekin & Asarnow (1998) reported no significant verbal working memory impairments in children with ADHD, in contrast with this study’s findings.

Another recent study evaluating cognitive abilities in children with ADHD and LI using a factorial design presented a different set of findings. Cohen et al.’s (2000) analysis of working memory performance of ADHD children found scores on both verbal and spatial working memory tasks to be more related to LI versus ADHD. The discrepancy between these and above reports may be attributable to differences in tasks used to assess working memory. For example, one task in the Cohen et al. study (2000) was the frequently used Daneman & Carpenter task (1980), in which the task items involve processing language at the sentence and word levels. Performance on this type of task will likely be confounded with language processing deficits, and conclusions are difficult to draw regarding the source of the working memory deficits.

This study found evidence of significant deficits in both spatial span and spatial working memory in the ADHD group, using tasks that required processing of sequential spatial information. Recent studies by Williams et al. (2000) and Kempton et al. (1999) also reported that their ADHD samples showed significantly reduced spatial short-term and spatial working memory abilities compared with normal children using a series of tasks from a computerized battery of memory tasks, the Cambridge Neurological Test Automated Battery (CANTAB) (Sahakian & Owen, 1992). Although direct comparisons of findings across studies are difficult to make because of differing ages and clinical criteria for group classification, and task differences, it is noted that spatial span was assessed in
these two studies using a computerized version of the Corsi block task, which requires memory for sequences of blocks of increasing length. The present findings also showed significantly poorer spatial span using the Finger Windows task which involves reproduction of spatial sequences of increasing length. Taken together, these findings across tasks and research samples suggest that processing of sequential spatial information may be particularly difficult for children with ADHD, and that this may be an important cognitive deficit in their profile that has previously been unrecognized.

Many earlier studies of nonverbal cognitive deficits in children with developmental language difficulties implicated spatial memory abilities as a common deficit in this population. Review of this literature, however, suggests that many of these studies were not designed within the context of established theoretical models of working memory. The present study may be one of the first to report findings of spatial span and working memory deficits specific to sequential information in children with LI. However, the finding of similar results across the three clinical groups precludes the possibility that these deficits are specific to either ADHD or LI. Furthermore, findings of working memory deficits in other samples of children, for example with SLI, RD and psychiatric disorders (Swanson 1999; Cohen et al., 2000; Pennington & Ozonoff, 1996) suggest the possibility that working memory deficits are themselves a developmental cognitive outcome of some other neurodevelopmental dysfunction that underlies developmental disorders of childhood. Further clarification of the specificity and severity of working memory deficits in children with specific clinical profiles such as ADHD and LI would require systematically addressing the subcomponents of working memory across the various types of tasks used so far in this area of research.
4.6 Listening Comprehension and Working Memory

Comprehending lengthy and complex spoken discourse is clearly a challenging task, as it involves coordination among many interdependent language and cognitive skills (Samuels, 1987). Furthermore, comprehension is mediated by other factors such as background knowledge, motivational factors such as the individual's goals in listening, and selective use of processing control strategies (Frederiksen et al., 1990). Comprehension of complex discourse such as that used in spoken expository passages requires coordination between basic level language skills, such as comprehension of syntactic and grammatical elements of language, and higher level language skills, such as comprehending how cohesive devices connect ideas in discourse. In addition, the listener's familiarity with various genres of discourse (e.g., narrative versus expository) and their associated organizational structures facilitates comprehension by signaling the need to adjust processing effort to match the specific type of discourse being processed.

In addition to the effects of basic language deficits on listening comprehension, it was hypothesized that working memory would also be an important predictor of comprehension performance. To determine the relative contribution of working memory to language comprehension performance in this sample, hierarchical regression models were developed involving key variables pertinent to the sample and research questions. These regressions suggested that both verbal and spatial working memory abilities are associated with generating inferences, but verbal working memory seems to make the primary contribution to comprehending and recalling facts. One clinical implication regarding this finding is that although spatial working memory may play only a minor role in listening comprehension, deficits in this area that co-occur with other language related
deficits (i.e. verbal working memory, basic language deficits) may have an impact on comprehension in tasks that require visual representations. For example, normal children who have well-developed language abilities and greater verbal and spatial memory capacities will be more readily able to activate and utilize both verbal and visual representations of information when listening to complex information. Children who have weak language and working memory skills (e.g. as in the ADHD group) or clearly identified language deficits together with poor working memory skills (i.e., as in the ADHD+LI and LI groups), will be at a distinct disadvantage in listening situations where comprehension is in part facilitated by visual representations of information (i.e. making inferences). For the ADHD group, which appeared to show language abilities slightly below those of the Normal group but above those of the two LI groups, their poor performance on questions requiring generation of inferences may reflect the effect of a combination of weaker language skills and deficits in spatial span and verbal and spatial working memory.

**Processes Associated with Inferencing**

The literature on reading comprehension offers the most well-developed models of the process of constructing inferences during comprehension. Graesser et al. (1994) and Haenggi et al. (1995) propose that when reading narratives, individuals construct a “situation model” of the overall meaning of the text, based on scripts and background knowledge, and actively search for validation of the model during reading. Inferences can be generated both “on-line” (i.e., during comprehension) and “off-line” (e.g., during a retrieval task). This process makes varying demands on working memory resources depending on whether the inferences are generated from background knowledge (low
demand) or whether they are based on novel information (higher demand). As expository texts are more decontextualized than narratives, and are usually written to inform the reader or listener, relatively fewer inferences are generated “on line” during reading of expository text compared with narratives (Graesser et al., 1994). It is also more likely that inferences generated from expository discourse will be based on novel information, with greater overall cost to working memory resources. The limited working memory abilities evident in children with ADHD in this study could explain their relative difficulty in generating “higher cost” inferences from the novel information presented in the expository listening passages.

Inferences are one of the higher level “products” of comprehension that are affected by reduced working memory capacity, as viewed from the Just and Carpenter (1992) model. The relatively greater proportion of “high working memory cost” inferences in processing expository passages may have taxed the already limited working memory resources of the children in the ADHD and LI groups. It is not clear however which aspects of the process of making inferences were deficient in these children, for example whether they made erroneous inferences, or whether they failed to generate the inferences in the first place. One possibility is that because of their working memory deficits, children with ADHD are not capable of generating as many inferences from lengthy and complex information as normal children. Another possibility is that when the process of generating inferences requires formation of verbal and/or visual mental representations, their verbal/spatial working memory deficits affect the quality and quantity of representations that they are able to create and maintain during processing. With respect to Baddeley’s model (1986) of working memory, in which the capacity of the system refers to the ability
of visual and verbal storage buffers to create, hold, and maintain information needed for processing functions carried on by the central executive, ADHD children's problems with spatial span and verbal and spatial working memory might limit their ability to encode and maintain mental representations (storage), thereby limiting the output of the central executive (processing).

In developing the tasks for this research, care was taken to avoid having expressive language deficits of children in the three clinical groups interfere with reliable assessment of their comprehension skills. Inferencing abilities were therefore tested two ways, using direct questions and True/False questions. True/False questions were predicted to be easier than the direct inference questions for the LI groups, as it was considered that the latter would place higher demands on verbal retrieval, which is difficult for children with LI. The True/False questions were also predicted to be easier because they presented a simple binary choice task and allowed the child to explain the rationale behind the True/False answers without being penalized for formulation difficulties.

A review of the results of the two sets of inference questions showed that scores on the direct inference questions were lower than for the True/False inference questions in the ADHD, ADHD+LI, and LI groups. The two tasks were therefore reviewed more closely regarding their specific processing demands. A task analysis of the True/False inference questions suggested that the child had to first comprehend the assertion that was being made, hold it in working memory while recalling specific information from the passage, reason whether it was True or False, and then explain his answer referring to the information in the passage that made the assertion incorrect. Although answering the True/False questions appeared to involve a multi-step process, the relatively better scores
on these questions suggested that they were easier than the direct inferences, despite making demands on working memory.

A potential explanation for this difference might be associated with different processes involved in retrieving the passage information while answering the two types of questions. Passage comprehension involves construction of mental representations during listening and retrieval of these during post-listening questions. The True/False question format provided one assertion, for which a mental representation would be made while the child was deciding whether it matched or did not match the passage information. In this case, only one mental representation would have to be held in working memory and considered for the response. In contrast, a task analysis of the direct inference questions suggested that the child had to actively search for and retrieve the meanings of two adjacent propositions within the text (i.e., retrieve two mental representations), and infer an implicit meaning related to the question. For example, in the “Cranberries” passage, two close propositions are “the buds turn into flowers” and “the fields turn a gorgeous shade of pink”. The child had to retrieve these two propositions in order to answer the direct inference question “what colour are the flowers of the cranberry plants?”.

With the suggestion from the regression analyses that both verbal and spatial working memory contributed to performance on inference questions, it was speculated that both verbal and visual representations of information from the passages might be encoded and held in working memory to successfully answer the inference questions. For example, in the “Mummies” passage, one of the True/False inference questions was: “The king was generous to others with his gold and riches” relative to the text reference that the king had all of his possessions buried with him in his tomb. In addition to holding the verbal
information in working memory, the child might also invoke a visual image of a tomb full of kings’ riches versus an image of riches being given away by the king in order to arrive at a response. If this were the case, then visual as well as verbal representations would have to be held in working memory while the child formulated a response to explain why the answer was False.

It is speculated that the apparently higher working memory and processing demands of the inference questions might have exceeded the processing capacities in children with ADHD, ADHD+LI, and LI for generation of an off-line inference (i.e., post-listening). Another possibility is that the children in the clinical groups had poorer access to and maintenance of verbal and visual mental representations while reasoning their responses, which could have made the inferences more difficult to generate on-line during listening or off-line during retrieval. The expressive language demands in providing answers to the inference questions may have also been an inhibiting factor for the ADHD children as the explanations involved discourse production skills to some extent. However, the emphasis on content versus formulation and the degree of scaffolding provided during the responses reduced the likelihood that this factor was responsible for the lower scores.

4.7 Theoretical Implications

One issue arising from this investigation concerns whether there is a connection between discourse deficits and executive function deficits in children with ADHD. Executive function deficits appear to be a consistent factor underlying ADHD symptoms (Seidman et al., 1997; Pennington & Ozonoff, 1996). A considerable number of studies have addressed the theory that a response inhibition deficit is the core executive function deficit underlying ADHD behaviours (see Tannock, 1998 for review; Barkley, 1997;
Schachar et al., 2000). Executive function deficits have long been associated with lesions or traumatic injury to the pre-frontal cortex in the frontal lobes. Individuals with frontal lobe syndrome deficits typically demonstrate marked difficulties in tasks that require executive skills such as planning, organization, strategic problem-solving, strategy shifting, and self-evaluation of performance.

Executive functions and language ability are closely associated with respect to development of self-regulation skills and performance of complex tasks, particularly as they relate to development of higher level communication and academic skills in children such as metacognitive abilities (Palincsar & Brown, 1984). According to Singer & Bashir, (1999), well-developed executive function skills are needed to organize and plan complex communications (e.g., such as production of spoken or written discourse), and well-developed language abilities are needed for the verbal mediation (i.e., “inner speech) that is used to guide complex task performance.

In studies of individuals with acquired brain injury involving the frontal lobes, associated impairments in executive functions have been found to affect competency in social interactions, organization of discourse, strategic use of memory functions, and strategic thinking (Ylvisaker & DeBonis, 2000). All of these skills are associated with ADHD symptoms, most notably the social communication difficulties and problems producing well-organized and coherent discourse observed in children with ADHD. Discourse production deficits that are commonly observed in children with ADHD in the form of pragmatic language difficulties, have previously been tied to the presumed executive function deficits in these children (Tannock & Schachar, 1996). Results of this
investigation suggest that this association between executive function and language deficits may also extend to the processing of discourse.

4.8 Clinical Implications

The findings of this study have important clinical implications which can be applied across disciplines involved with the assessment and treatment of cognitive and language deficits of children with ADHD. With regard to language assessment, while the standardized language measures (i.e., PPVT-III, EVT, CELF-3) were used primarily for classification of the two LI groups in this study, the data afforded an opportunity to compare the performance of ADHD and Normal groups on these measures. With the exception of the study by Oram et al. (1999), few studies of language abilities in children with ADHD have focused on their basic language abilities. In the present study, with the exception of scores on the PPVT-III and the Formulated Sentences and Listening to Paragraphs subtests from the CELF-3, the ADHD group appeared to be poorer than the Normal group on most receptive and expressive subtest and composite scores.

Although the ADHD and Normal groups’ performance on the PPVT-III (receptive vocabulary) was similar, there were significant differences in their performance on the EVT (expressive vocabulary). Relative difficulty of task demands and presence of co-occurring reading difficulties may explain this discrepancy in vocabulary scores. The fact that the PPVT-III is a recognition task where spoken words are matched with a picture and no verbal output is required, suggests that the processing demands of this test are relatively low compared with those of the other standardized language tasks. The PPVT-III is however, considered to be a valid and reliable estimate of the fund of words in an individual’s learned vocabulary. The significantly lower expressive vocabulary scores
(EVT) of the ADHD group may be a reflection of the high proportion (66%) of children in this group who showed poor decoding skills on the Word Attack subtest (WRMT-R). The EVT assesses expressive vocabulary by asking the child to produce a synonym for a stimulus word with an accompanying picture (e.g., stimulus: “rich” (picture of mansion): response: wealthy). Viewed from a different perspective, this task is also assessing word retrieval skills in a confrontation naming task format, where the child has to access a specific semantic network and retrieve an appropriate response, a skill which has been found to be significantly difficult for children with RD (Wolf & Bowers, 1999).

Although the ADHD children did not meet criteria for LI, they demonstrated consistently poorer scores on the CELF-3 subtests compared with the Normal group. As discussed earlier, these subtests appear to have fairly high working memory demands. Review of the correlations between the separate subtests and the working memory measures indicated that scores on the Word Classes, Semantic Relationships, and Sentence Assembly subtests were most highly correlated with working memory scores, and these were the tasks on which the ADHD group showed the lowest mean scores. More definite conclusions regarding the working memory demands of the CELF-3 would require a factor analytic approach, however the findings of this study suggest that this test should receive closer scrutiny in future regarding interpretation of language performance of ADHD children, both in clinical and research contexts.

The Listening to Paragraphs subtest from the CELF-3 is a standardized comprehension task for narrative passages that was used as a point of comparison with the listening passages designed for this study. Although the two test passages in this subtest appeared to be comparable to the experimental expository passages designed for this study
with respect to length and vocabulary level, scores on this task did not differentiate the two ADHD groups from the Normal group. This finding suggested that either this narrative task is not sensitive to the same language processing weaknesses demonstrated by the ADHD group on the expository passages, or that ADHD children find narrative passages easier in general to comprehend than expository passages. It should be kept in mind that the standard scores on this subtest reflected responses to a combination of factual and inferential questions and therefore cannot be directly compared to the comprehension analyses for the experimental expository passages, which separated the scores for comprehension of facts and inferences.

Given the above findings and those of previous studies of language production, both basic level and higher level language skills should be routinely assessed in all children referred to clinics and school services. In particular, listening comprehension skills should be assessed both with and without visual cues. Even for children who do not meet clinical criteria for LI, their apparently lower average language skills and weakness in making inferences during listening should be acknowledged as potential factors that might be associated with diagnostic behavioural symptoms that are frequently reported by parents and teachers, such as “poor listening”. Subtle comprehension deficits may also be associated with academic performance problems at school. Weak language processing abilities could also affect success of some therapeutic interventions that involve talking and listening, such as social skill programs and individual counseling. It would seem from the results of this and previous studies that language abilities are a central factor that need to be considered in clinical and diagnostic decisions regarding intervention for children with ADHD.
Given the multiple areas of language functioning potentially involved in children with ADHD (i.e., basic skills, discourse production, discourse processing), assessment of language ability is best accomplished using a series of standardized and non-standardized tasks which tap both basic and higher level skills. Discourse level tasks are difficult to find in existing standardized tests, however much useful information regarding a child’s functional language comprehension skills can be gained by adapting tasks in non-standardized formats and performing both off-line and on-line analyses. One cautionary note to speech-language pathologists who use the CELF-3 routinely is that the narrative passages in the Listening to Paragraphs subtest may not be a sensitive discourse level measure of listening comprehension in children with ADHD and ADHD+LI, as demonstrated in this investigation. Concerns have also been raised by others regarding clinical use of the Listening to Paragraphs subtest considering its reported weak test-retest reliability (Gillam, 1998; MacDonald, 1998). Therefore, conclusions regarding children’s discourse processing skills should not be drawn solely from performance on this task. Also, since previous research has shown adequate comprehension of facts in narratives in children with ADHD, clinicians should ensure that tasks chosen for comprehension assessments reflect more than just this one aspect of language processing.

Clinicians assessing language abilities in children with ADHD should also be cognizant of the working memory demands of assessment tasks, given findings in this and other studies of deficits in both verbal and spatial working memory, and the evidence in this study of a strong association between standardized language test scores and working memory scores. Subtests of standardized language tests vary in the degree of demands placed on working memory and other processing functions such as sustained attention and
multistep problem solving. Often, children perform relatively well on some comprehension tasks and not on others. Analyzing the processing demands of language tasks would be helpful clinically in qualifying interpretations of test results that are otherwise inconsistent and confusing.

Another clinical concern involves the comorbidity of RD with both ADHD and LI. The notion of RD in children with ADHD being tied mainly to deficits in basic language abilities was not supported by the profiles of the ADHD group in this sample. 66% of the ADHD group who had average language test results had scores below 85 (i.e., 1 SD below the mean) on the Word Attack subtest of the WRMT-R and were reported by their parents and teachers to be having significant academic difficulties at school.

The evidence that children with ADHD are poorer than normal children in comprehending inferential information in expository discourse raises the question regarding whether they also have difficulty making inferences from other types of spoken discourse, such as narratives and conversation. The ability to make inferences from communication in social situations would appear to be particularly relevant to the pragmatic language problems that are characteristic of ADHD. Poor comprehension of subtle meanings and intentions of others could affect the timing and appropriateness of children's responses in conversations, especially in groups, and affect their opportunities for successful participation in social activities. These issues are highlighted in the work of Cohen et al. (1998a) who found that children with psychiatric disorders and co-occurring LI showed poorer ability to understand social and emotional cues and with solving social problems. Since ADHD is the most frequent diagnosis in psychiatrically-referred children
with LI, the area of inferencing in social discourse will be an important area for future research.

4.9 Educational Implications

The functional effect of ADHD on cognitive development, learning, and achievement is of considerable interest to educators. While the co-occurrence of ADHD with RD and LI significantly increases academic risk, the core behavioural symptoms of ADHD also affect children’s success in the classroom. This study’s findings suggested a link between poorer inferencing abilities in this sample of children with ADHD and working memory deficits. Since most of the instructional language used at school is in the expository genre (Wallach & Miller, 1988), these findings have several implications for teaching practices.

The consequences of poor inferencing abilities may be observed in the poor self-regulation and metacognitive skills common in children with ADHD (Ylvisaker & DeBonis, 2000). Metacognitive ability refers to skills such as thinking about one’s own thinking processes, evaluating and monitoring task performance, and developing and applying strategies to solve complex problems. Well-developed metacognitive skills are critical to academic achievement since many everyday tasks at school require children to consciously reflect on what they are learning and how they are performing. For example, they must be aware of how new information modifies concepts developed from past learning, recognize the goals of assignments (i.e., what the teacher wants them to do), and adjust their task approach and effort accordingly. This type of metacognitive awareness is rarely taught explicitly in classrooms of normal learners, and arises largely from making inferences from instructional language. Although training in metacognitive awareness has
been a specific aspect of remedial programming for students with learning disabilities (Palinscar & Brown, 1984), these skills must be developed independently by children in regular classrooms during instructional language and learning experiences. Children who are poor at making inferences when listening to instructions and explanations will be less able produce their work efficiently and independently, and may require explicit instruction regarding use of metacognitive strategies toward these goals (Palinscar & Brown, 1984; Wallach & Miller, 1988).

The finding of subtle language processing difficulties in children with ADHD also has implications for teachers’ evaluations of children’s performance strengths and weaknesses in the classroom, and application of specific teaching strategies. Some teachers may overestimate comprehension abilities of ADHD students whose language skills appear to be average on the surface, and attribute their poor classroom performance to inconsistent effort or non-compliance. The frequent report of teachers that “he could do it if he wanted to” is often based on their frustration in working with a child who shows inconsistent performance across situations. Again, as processing demands vary across situations, so may the child’s ability to process information or complete work in a timely manner. Multiple factors in a classroom environment can disrupt listening and information processing conditions such that many children miss spoken information, fail to associate important ideas, and need repetition of instructions and explanations.

In this study, children with ADHD were poor at comprehending implicit meanings in spoken information. This finding suggests that teachers should frequently check for understanding of inferential meanings from classroom content. Additionally, reinforcement of concepts using cues in other modalities (i.e. pictures, print, graphic organizers) as with
other students with learning difficulties may better ensure that implicit meanings in texts and in verbal lessons are understood. Thirdly, teachers may have to anticipate the need for reinforcement of complex verbal information with other cues, as children with ADHD and LI may not be aware of or signal their own comprehension failures. ADHD children were also poor at monitoring comprehension of sequenced instructions in ideal listening conditions, and did not benefit as much as normal children from verbal repetition of information to identify factual inconsistencies. These findings suggest that teachers should anticipate comprehension difficulties for sequential task instructions in children with ADHD. Also, simply repeating information verbally (i.e., in the same modality) for these children may not be as effective in facilitating improved comprehension as it is with normal children.

Another educational issue concerns the possible effect of listening comprehension deficits on development of reading comprehension skills. The link between listening and reading comprehension has been acknowledged over many years of research in reading and learning disabilities (Samuels, 1987; Vellutino, 1993). In students with ADHD who have normal word identification skills (36% of the sample in this study), there may be a high risk of teachers missing reading comprehension problems, and attributing poor academic performance to other behaviours associated with ADHD. For children with ADHD+RD, remedial programs at school must first focus on basic skill development (e.g., development of basic decoding skills) and improve competency in oral language skills before reading comprehension issues can be addressed. Children with ADHD+RD+LI will pose the greatest challenges to teachers and learning specialists with respect to analyzing deficits and developing efficacious programs for remediation of learning deficits in addition to
managing other academic and social consequences of the ADHD symptoms (AACAP, 1997).

One last point concerns the observation of high ratings of anxiety by teachers in many children in the three clinical groups who did not receive these ratings by their parents. The specific effect of language processing difficulties on children's behaviour and self-esteem has not been previously investigated, however environments that place high demands on verbal proficiency and assume normal comprehension abilities (i.e., such as at school) are likely to produce stress and worry in children which may add to the already disabling effects of their particular developmental disability, whether it is ADHD or LI or both. Teachers' awareness of the anxiety levels of many of their students would add to the effectiveness of their efforts to deal with their social and academic learning needs.

4.10 Limitations of This Study

The findings of this study should be interpreted with respect to the following qualifications and limitations. One possible limitation is that the ADHD groups comprised children with both Combined Type and Inattentive type of ADHD. As there is recent evidence that the two main symptoms underlying these subtypes (i.e., inattention, hyperactivity/impulsivity) may be related to different underlying neuropsychological factors, the fact that the groups were mixed may have masked potential performance differences of these two ADHD subtypes on the language, reading, and listening comprehension measures. (Baumeister et al., 2000). The additional fact that well over half of the two ADHD groups also had poor word attack scores, resulting in some of the children in the ADHD+LI group also showing RD, further complicates separation of performance patterns associated strictly with ADHD.
The ADHD+LI and LI groups appeared to perform in a surprisingly similar manner with respect to quantitative evaluation of their performance in the language, reading, and comprehension measures. Analysis of qualitative differences in their responses on the above measures was beyond the primary objectives of the study, although future investigation might expose more distinct performance patterns that would differentiate the ADHD+LI from the LI group.

Another issue concerns task development and methodology used to assess comprehension abilities. Assessing comprehension is a challenging process both from clinical and theoretical perspectives. The listening comprehension tasks in this study were off-line measures, that is, post-listening inferencing and retrieval processes were needed to answer the comprehension questions. Therefore, it cannot be concluded with certainty which aspects of the processing of inferences and comprehension monitoring were deficient in the clinical groups. An alternate methodology utilizing the “think-aloud” task (Ericsson & Simon, 1984) would offer a way to conduct on-line assessment of comprehension processes during listening. In this paradigm, individuals reflect directly and verbally on information that is heard or read. Although analysis is time-consuming and data are more difficult to quantify, analysis of direct verbal reflections of information would offer potentially valuable insights into where comprehension skills begin to break down in children with ADHD.

One further limitation concerns the lack of differentiation of the ADHD and ADHD+LI groups in this study. Although the ADHD+LI group met the rigorous classification criteria for ADHD, it must be kept in mind that these arose from behavioural ratings. Pennington et al. (1993) were able to show a double dissociation between ADHD
and RD, using an executive function measure as confirmatory evidence of ADHD. This type of measure was not used in the test protocol in this study. Also, given restrictions imposed on the number of possible comparisons using the planned contrasts analyses, it was not possible to determine differences in language comprehension performance between the ADHD and ADHD+LI groups. Further comparisons of language and cognitive abilities between these two groups should be a priority of future investigations.

A final issue is the exclusion of girls with ADHD and LI from the present sample. Considering that this study was the first to investigate listening comprehension in depth in children with ADHD, and the fact that presentation of ADHD symptoms and comorbid disorders may vary between boys and girls, it was decided to first concentrate on comprehension performance in boys. Future investigations should focus on whether language performance varies in girls with ADHD.

4.11 Conclusions

This dissertation attempted to address the under-researched area of listening comprehension abilities in children with ADHD and LI, two common but extremely complex neurodevelopmental disorders that often co-occur. Drawing from the current clinical literature associated with ADHD and SLI, and the fields of cognitive psychology and discourse processing, it was possible to design experimental listening comprehension tasks that differentiated performance of children with ADHD from normal children and children with and without LI.

This study found evidence of subtle deficits in listening comprehension skills in children with ADHD who had otherwise average language abilities for their age. Specifically, children with ADHD showed poorer comprehension of inferences and
monitoring of sequential information in spoken expository passages compared with normal children. Children with ADHD also showed significantly poorer verbal and spatial working memory abilities compared with normal children. Verbal and spatial working memory together predicted about 15% of the variance in scores on inference questions from the listening comprehension tasks used in this study, suggesting that both aspects of working memory may be needed for listening comprehension. The use of a community sample in this investigation enhances the generalizability of these findings to children with ADHD and LI in the public school population.

As the original research questions focused mainly on the ADHD group, conclusions are highlighted with respect to main performance differences between the ADHD group and the Normal group. This focus was chosen at the outset of the study since there is a need in the field to determine specific cognitive factors underlying this disorder which is diagnosed solely with respect to behavioural symptoms. One concern motivating this investigation was that children with ADHD may experience frequent misattribution of their behavioural symptoms by parents, teachers, and friends. If their language and cognitive deficits are not acknowledged or understood, repeated failures in task performance and social interactions will further influence the outcomes of this already disabling disorder.
References


Appendix A

Parent and Teacher Ratings on Conners Rating Scale-R Indices for Oppositional Defiant Disorder and Anxiety

1. Oppositional Defiant Disorder Index (T-scores)*

<table>
<thead>
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<td>ADHD+LI n=18</td>
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<tr>
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<td>T-score</td>
<td>T-score</td>
</tr>
<tr>
<td>6TW 66</td>
<td>30JO 70</td>
<td>1BB 73</td>
</tr>
<tr>
<td>4CM 78</td>
<td>57JC 85</td>
<td>21CW 68</td>
</tr>
<tr>
<td>5SD 66</td>
<td>93JS 73</td>
<td>50RW 75</td>
</tr>
<tr>
<td>14JA 68</td>
<td>103DT 80</td>
<td>87KC 90</td>
</tr>
<tr>
<td>15CI 82</td>
<td>8JY 69</td>
<td>90SC 69</td>
</tr>
<tr>
<td>18SH 66</td>
<td>38MN 85</td>
<td>48NH 69</td>
</tr>
<tr>
<td>28CB 69</td>
<td>86GL 68</td>
<td>77BB 91</td>
</tr>
</tbody>
</table>

* individual children whose scores were >65 on both parent and teacher ratings are indicated in bold print

Totals: Parent Ratings  %  Totals: Teacher Ratings  %
ADHD 11/21 52.3  ADHD 11/21 52.3
ADHD+LI 7/18 38.9  ADHD+LI 7/18 33.3
LI 5/19 26.3  LI 4/19 21
### 2. Anxiety Index (T-Scores)*

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<td>T-Score</td>
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<td>18SH 72</td>
<td>66MK 66</td>
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* individual children whose scores were >65 on both parent and teacher ratings are indicated in bold print

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<th></th>
<th>Totals: Parent Ratings %</th>
<th>Totals: Teacher Ratings %</th>
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</thead>
<tbody>
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<td>ADHD 9/21 42.8</td>
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<tr>
<td>ADHD+LI</td>
<td>4/18 11.1</td>
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<tr>
<td>LI</td>
<td>2/19 15.7</td>
<td>LI 8/19 42.1</td>
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Appendix B

Expository Passage Comprehension: Administration, Measures, and Scoring

A. Task Administration

1. Instructions for passage comprehension tasks

"Sometimes at school, you have to listen to explanations and descriptions of things with no pictures. You have to listen carefully so that you understand and remember what the teacher said as well as you can. You are going to hear some explanations on tape, but there are no pictures. You have probably heard of these things before, but you are going to hear some new information that you probably didn’t know. After you listen, I’ll ask you some questions about what you heard. Let’s do a practice one first, so you know what to do. This is an explanation about how fire extinguishers work.”

Trial passage: Fire Extinguishers - followed by questions

“Now, here is another explanation - this one is about “mummies” - child listens to each test passage followed by the factual and inferential questions

2. Eliciting responses to comprehension questions

- the goal is to elicit an optimal response with specific detail so that it can be determined whether or not the concept in the question was understood

- the examiner should avoid telling the child if the response was correct or incorrect - comments such as “OK, here’s another one”, or “That was a good answer” are appropriate

- vague or incomplete responses should be followed by prompts for more detail

- the number of prompts should be kept to a minimum (e.g., not more than 2) to avoid making scoring decisions more complex - prompts should be of the following types, for adding detail or clarifying responses, or providing a rationale for the response (Examples) “tell me more”, “explain it a bit more”, “anything else?” or repeat phrases or vocabulary verbatim from the child’s response, e.g., “what do you mean by __________?”

- the question should be repeated if the child requests it, or if it appears that the question was misunderstood (e.g., misinterpreting a “who” for a “where” question).

- for T/F inferential questions, correct T/F responses require a supporting explanation; prompt the child with “why do you say true” or “why do you say false?”
- if the child does not respond, allow a few more seconds to think about a response and then move on if a NR is evident; reassure the child and encourage him to try another question (e.g., "Not sure about that one? That’s OK, try this one")

- responses are given some credit if they indicate partial understanding of the target facts or inferences - the examiner must decide whether the child has provided his best response

3. **Rationale for scoring decisions:**

- scoring should focus on the content of the response not on the formulation

**Factual questions:**

- full credit responses are taken directly from the text - content is specific but verbatim wording is not required - score 2

- partial credit responses part or one element of the complete correct answer one element plus an error (e.g., eels: #1 - "**muscles** and bones") score 1

**Inferential questions:**

- full credit responses demonstrate understanding of target inferences taken from the passage - refer to "text reference" in scoring guide score 2

- partial credit responses demonstrate incomplete understanding of target inferences or reliance on logic or background knowledge (i.e. schema) score 1

**T/F Inferential Questions**

- correct T or F responses must be supported by an explanation regarding the target inference from the text - refer to "text reference" in scoring guide score 2

- partial credit explanations demonstrate reliance on logic or background information instead of the target inference in the text score 1

- no credit is given for explanations that appear to be driven by logic but demonstrate faulty comprehension of the target inference in the text use prompts to verify that concept was not understood score 0

- incorrect T/F responses are scored 0

**Trial Passage: Fire Extinguishers** (194 words; 11 sentences)

Fire extinguishers are important safety equipment for schools or hospitals. A fire extinguisher works kind of like a big spray can except that instead of water inside it, it contains carbon dioxide gas. The carbon dioxide is under high pressure, which means that a lot of gas is forced into the tube and not allowed to escape. The carbon dioxide is kept inside the tube with a tight stopper which gets released when someone operates the fire extinguisher. Fire extinguishers come in different sizes. For the larger ones you have to be very strong to lift them, but they are quite easy to use. If you have a real fire, hold the fire extinguisher about 4 feet away from the flames. Be careful to point the nozzle away from you and towards the flames. When you push down on the handle, the gas is released from inside the tube and turns into thick white foam when it comes out the nozzle. The foam puts out the flames quickly by covering them with carbon dioxide. For a smaller fire, if no oxygen can get near the flames, it should go out in about 10 seconds.

**Factual Questions:**

1. What is inside the tube in the fire extinguisher?  carbon dioxide gas
2. How the gas kept inside the fire extinguisher? tight stopper, pressure
3. What happens when you push down on the handle? white foam comes out
4. How far away from the flames should you hold the fire extinguisher? 4 feet

**Inferential Questions:**

1. What does a fire need to keep on burning? oxygen
2. What size of fire extinguisher could a kid your age use? smaller/lighter one
3. How long does it take to put out a small fire? 10 seconds

**T/F Inferential - explanation for correct responses**

1. Fire extinguishers are good at getting rid of smoke.  F
2. Carbon dioxide gas could save someone's life.  T
3. Only people who take lessons can use a fire extinguisher.  F

Making Mummies (235 words; 13 sentences; Chall-Dale level: Grade 5-6)

Do you know how mummies were made? In ancient Egypt, kings believed they could live forever after they died by turning their bodies into mummies that would not rot or decompose. When a king died, priests from the temple went to work to turn his body into a mummy. It took about two months to get the body ready to be buried in one of the great pyramids. First, the blood was drained out of the body, and then the priests took out the brain, heart, liver, and stomach. Each of these was kept in a special jar and buried with the mummy later on. Next, the body was dried with salt, and then special oils were rubbed into the skin to keep it soft. After it was all dried out, the body was wrapped with long strips of thin linen cloth. The priests put the king’s jewelry and precious stones in between the layers of cloth. When the body was all wrapped, sweet smelling oils were poured all over it and allowed to soak in over several weeks. Then, the mummy was put into a c coffin and lowered deep into the pyramid through a secret passageway. Larger valuables like gold vases and statues went down into to the king’s tomb with the coffin. Finally, the entrance to the passageway was sealed up forever so that no one could disturb the king in his afterlife.

Factual Questions:

1. Who turned the king’s body into a mummy?  priests
2. Why did the king want his body made into a mummy?  to last forever
3. What was used to dry the king’s body?  salt
4. What happened to the inside parts of the king’s body?  in jars
5. How did they get the mummy’s coffin into the pyramid?  secret passageway
6. Where were the king’s jewelry and precious stones kept?  in layers of cloth

Inferential Questions:

1. What did the mummy smell like when it was put in the tomb?  sweet smelling oils
2. What did the king think he would need in his afterlife?  jewelry, gold
3. Who knew where the mummy’s tomb was located?  priests
4. What did the mummy’s face look like before burial?  covered in cloth
5. Why did it take so long to turn the body into a mummy?  had to dry out body

T/F Inferential Questions - with explanation for correct responses

1. The king was afraid of living in his next life.  F
2. The king was generous to others with his gold and riches.  F
3. The king’s entire body was buried in the pyramid.  T
4. People could go and pray to the king in his tomb.  F
5. Only certain people knew how to turn a body into a mummy.  T


**Making Baked Alaska** (235 words; 14 sentences; Chall-Dale level: Grade 5-6)

Have you ever had a fancy dessert called Baked Alaska? To make it successfully, everything must be done quickly and at exactly the right time. The ingredients include an angel food cake, ice cream, and sugar. First, you slice an angel food cake into thin layers and place one layer of cake in the bottom of a baking dish. Save the other layers of cake for later. Next, you whip up 6 egg whites with a bit of salt in a glass bowl making a meringue just like on a lemon meringue pie. Add a cup of sugar to the egg mixture, beating it in a bit at a time until it turns white and puffy. Put this aside for a minute. Then, go back to the baking dish and put 2 litres of vanilla ice cream on the layer of cake in the bottom of the dish. Make the top of the ice cream rounded with a spoon and then put the remaining layers of angel food cake on top of it. Then, cover the whole thing with the whipped meringue, making sure that it completely covers all the angel food cake. Finally, quickly place the baking dish in a hot oven, about 500 degrees. Allow it to bake for not more than 3 minutes, watching it closely until the meringue starts to turn brown and shiny. Remove and serve immediately to your guests.

**Factual Questions**

1. What goes into the bottom of the baking dish? 
   - angel food cake

2. How many egg whites do you need for the meringue? 
   - 6

3. What do you put on top of the ice cream? 
   - rest of angel food cake

4. How long do you let it bake in the oven? 
   - 3 minutes or less

5. When should you serve it after it comes out? 
   - serve immediately

6. What does it look like when it is ready to come out of the oven? 
   - turns brown and shiny

**Inferential Questions:**

1. What is in the centre of this dessert? 
   - ice cream

2. What will the meringue taste like? 
   - sweet, like sugar

3. What if you waited an hour before baking it? 
   - ice cream would melt

4. What colour is the dessert before you bake it? 
   - white

5. Why do you bake it for only 3 minutes? 
   - ice cream would melt

**T/F Inferential Questions:**

1. People could serve this dessert on a special occasion. 
   - T

2. You could make this dessert the day before you want to eat it. 
   - F

3. The inside of this dessert will be very hot. 
   - F

4. This dessert would be easy for children to make. 
   - F

5. You should take lots of time to make this dessert properly. 
   - F


**Growing Cranberries** (236 words, 13 sentences; Chall-Dale level: Grade 5-6)

Have you ever seen a cranberry farm? Most people know about cranberries as something you have with turkey or that is made into juice, but they might not realize how difficult it is to produce cranberries. Cranberries are grown out west in B.C. in low-lying swampy fields that have moist soil. The farmers first plant the seeds in the fall and they develop slowly over the winter. By springtime, the buds appear on the plants, but then the farmers have to battle frost and insects to keep them alive. In early spring, the farmers keep the plants underwater so they don’t freeze during night frosts. Later on, they spray chemicals on the buds to keep them from being eaten by caterpillars, their worst enemy. By summertime, the buds turn into flowers and the fields turn a gorgeous shade of pink. Then, after the bumble bees pollinate the flowers, they finally turn into red berries by late summer. Cranberries are not picked by hand, like other kinds of berries, but by a machine. The farmers first flood the fields with millions of litres of water, and then they push a special plough through the fields that knocks the berries right off the vines. The berries float up to the surface and the farmers rake them up into huge piles. Finally, they are loaded onto big trucks and taken away to the juice factory or to the supermarket.

**Factual Questions:**

1. **What kind of soil is needed to grow cranberries?**
   - moist

2. **What is the cranberry plant’s worst enemy?**
   - caterpillars

3. **How do the farmers keep the cranberry plants from freezing?**
   - keep them underwater

4. **How does the special plough get the cranberries off the vines?**
   - knocks them off vines

5. **When are the cranberries ready to be picked?**
   - late summer

6. **What do the farmers do to the fields before picking the berries?**
   - water

**Inferential Questions:**

1. **How do chemicals help the young cranberry plants?**
   - kill caterpillars

2. **What colour are the flowers of cranberry plants?**
   - pink

3. **What does the field look like when the farmers gather the berries?**
   - covered with water

4. **Which insects help with growing cranberries?**
   - bumble bees

5. **What do cranberry farmers need a big supply of?**
   - water

**T/F Inferential Questions - with explanation for correct responses**

1. Cranberries take a long time to grow.  
   - T

2. There are many cranberry farms in southern Ontario.  
   - F

3. You can pick cranberries just like you pick strawberries.  
   - F

4. Farmers wear high rubber boots when they pick cranberries.  
   - T

5. You could grow cranberries in the mountains.  
   - F

Electric Eels (233 words; 12 sentences; Chall-Dale level: Grade 5-6)

Why do electric eels give off electric shocks in the water? For one thing, they use their electric power for survival, to kill their prey and to defend themselves. They also use their electric power like radar to see through the murky ocean water, since electric eels are almost totally blind by the time they are adults. Inside the eel’s tail are three small organs made up of muscles and nerves, which act like batteries. Full-grown electric eels can produce quite a lot of electricity, enough to light up 10 light bulbs at the same time. First, the eel is always sensing the water around it, and can tell if something nearby is a rock or another fish. When the eel senses something moving close by, it sends out an electric shock from its batteries that lights up the water. Then, the electric shock bounces back from whatever it hits, and tells the eel how far away and how big the object is. The shock could either scare the object away or it might also kill it. After that, if the object is small and moving, the eel will go after it thinking it is food. But it might be something bigger and more dangerous, like a larger fish or shark. Then the electric shock helps the eel calculate how far away it is so it can quickly escape to a safer spot.

Factual Questions:

1. What are the organs that work like batteries made out of? muscles and nerves
2. How much electricity do electric eels produce? light up 10 light bulbs
3. What makes the eel send out an electric shock? senses object nearby
4. What does the electric shock do after it hits something? bounces back
5. What does the electric shock tell the eel? how far away/ how big
6. What part of the eel do the electric shocks come from? from the tail

Inferential Questions:

1. How does the eel know something close by is dangerous? large moving object
2. Why does the eel use electric shocks to find food? blind
3. Why would an electric eel stay near some rocks? hide from larger fish
4. What are the small moving objects that the eel goes after? small fish
5. What would happen to the eel if its batteries stopped working? starve, get killed

T/F Inferential Questions - with explanation for correct responses

1. Electric eels are always trying to attack other sea animals. F
2. Younger eels can see better than full-grown eels. T
3. Eels can tell if moving objects are dangerous or not. T
4. Eels are afraid of smaller moving objects. F
5. People could tell if electric eels were in the water near them. T

### Scoring Criteria for Expository Comprehension Passages

<table>
<thead>
<tr>
<th>Question</th>
<th>Correct Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Who turned the king’s body into a mummy?</td>
<td>priests</td>
<td>2</td>
</tr>
<tr>
<td>2. Why did the king want his body made into a mummy?</td>
<td>wanted to live forever</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>reference to afterlife</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to preserve his body</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>so his body wouldn’t rot</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wanted his body to last longer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>so he could live longer</td>
<td></td>
</tr>
<tr>
<td>3. What was used to dry the king’s body?</td>
<td>salt</td>
<td>2</td>
</tr>
<tr>
<td>4. What happened to the inside parts of the king’s body?</td>
<td>taken out and put into jars</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>or put into jars</td>
<td></td>
</tr>
<tr>
<td></td>
<td>taken out</td>
<td>1</td>
</tr>
<tr>
<td>5. How did they get the mummy’s coffin into the pyramid?</td>
<td>through a secret passageway or door; key idea: secret</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>lowered it down through a passageway, trap door</td>
<td>1</td>
</tr>
<tr>
<td>6. Where were the king’s jewelry and precious stones kept?</td>
<td>in or between layers of cloth</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>mentions wrong cloth</td>
<td>1</td>
</tr>
</tbody>
</table>
Inferential Questions:

1. What did the mummy smell like when it was put into the tomb?

   Text reference: the priests put sweet smelling oils on the mummy

   correct: like sweet oils, nice, good
   (ref. to “good smell” and “oils”) 2

   partial: like perfume, like the stuff they put on him 1

2. What did the king think he would need in his afterlife?

   Text reference: he was buried with his precious stones, vases and statues

   correct: jewelry, precious stones, statues, gold vases (specific) or reference to riches 2

   partial: body parts
   peace and quiet
   life again

   no credit: money 0

3. Who knew where the mummy’s tomb was located?

   Text reference: priests put mummy in tomb through secret passageway
   tomb location kept secret

   correct: priests 2

   partial: people that put him there
   or * 1

* if child maintains consistency with answer for #1F (e.g., who made the mummy - “doctors” - who knew where the mummy’s tomb was located - “doctors” - allow a partial score)

4. What did the mummy’s face look like when it went into the coffin?

   Text reference: body was completely wrapped in white linen cloth

   correct: couldn’t see face, wrapped up, covered in white strips of cloth 2
5. Why did it take so long to turn the body into a mummy?

Text reference: the body had to dry out, the oils had to soak in, there were many steps involved

- correct: had to dry it out, had to let oils soak in for a few weeks 2
- partial: reference to a lot of steps or listing 2-3 steps 1
- no credit: reports only one of the steps 0

T/F Questions:

1. The king was afraid of living in his afterlife. (F)

Text reference: he wanted to pass on to his afterlife

- correct: he wanted to live in his afterlife looking forward to it 2
- partial: reference to life after death he wanted to live longer 1

2. The king was generous to others with his gold and riches. (F)

Text reference: took precious possessions with him (e.g. statues and gold vases)

- correct: he took it with him 2
- partial: kings don’t usually give away their gold kings are usually greedy 1

3. The king’s entire body was buried in the pyramid. (T)

Text reference: even thought body parts were taken out they were buried with him

- correct: jars went to the tomb with coffin 2
- partial: put his body in the tomb 1
4. People could go and pray to the king in his tomb. (F)

Text reference: secret passageway, sealed up, location was kept secret

- correct: no one could get in because it was all sealed up, locked up, etc. or: only the priests knew where it was or only the priests knew where the secret passageway was
- partial: reference to the king not wanting to be disturbed

5. Only certain people knew how to turn a body into a mummy. (T)

Text reference: the priests were the ones who did this special process, implies that they would need special training or were the “selected” ones for the job

- correct: ref. to only the priests, it was their job, had to know how to take out body parts, wrap it up, etc., reference to special skills or being trained to do it
- partial: they wouldn’t want just anyone taking out the king’s organs

2. Making Baked Alaska

1. What goes into the bottom of the baking dish?

- correct: a layer of angel food cake or angel cake (angel fruit cake OK) or a layer of cake
- partial: cake, ref. to wrong type of cake
- no credit: angel pie (*except, see # 3 below)

2. How many egg whites do you need for the meringue?

- correct: 6
3. What do you put on top of the ice cream?
   
   correct: rest of angel food cake  
   more cake  
   
   partial: more of what is referred to in #1  
   (i.e., understands that it is the same ingredient)

4. How long do you let the dessert bake in the oven?
   
   correct: 3 minutes or less  
   
   partial: a few minutes, or # close to 3

5. When should you serve it when it comes out?
   
   correct: right away, immediately  
   
   partial: one of: brown, shiny

6. What does it look like when it is ready to come out of the oven?
   
   correct: brown and shiny  
   (accept sparkly)  
   
   partial: one of: brown, shiny

Inferential Questions

1. What is in the centre of this dessert?
   
   Text reference: ice cream is between layers of cake  
   
   correct: ice cream

2. What will the meringue taste like?
   
   Text reference: ingredients for meringue are egg whites and sugar  
   
   correct: sweet like sugar
3. What if you waited an hour before baking it?

Text reference: have to make it quickly and bake it quickly/ ice cream would melt

- correct: ice cream would melt 2
- partial: it would go all runny/ soggy/ gooey (ref. to wet from melting) 1
- no credit: it would go bad, rot 0

4. What colour is the dessert before you bake it?

Text reference: top layer is meringue which looks white and puffy

- correct: white 2

5. Why do you bake it for only 3 minutes?

Text reference: ice cream is between layers of cake - short baking time allows inside to stay cold and outside to be hot/ more than 3 minutes, ice cream would melt

- correct: ice cream would melt 2
- partial: temperature is so high very hot 1
- no credit: it would get burned 0

T/F Questions:

1. People could serve this dessert on a special occasion. (T)

Text reference: it’s fancy, special, unusual, can make it fast

- correct: it’s fancy, can make it fast 2
- partial: ref. to ice cream, birthday party, etc. 1
2. You could make this dessert the day before you want to eat it. (F)

   Text reference  have to make it fast, bake it, and serve it right away

   correct: have to serve it right away
   partial: it would go all runny

3. The inside of this dessert will be very hot. (F)

   Text reference  cold on inside because of ice cream

   correct: it’s ice cream

4. This dessert would be easy for children to make. (F)

   Text reference  timing has to be exact for dessert to turn out right, implies skill needed

   correct: have to do everything at the right time
   ref. to being complicated, many steps

   partial: kids can’t use the stove, make a mess, can’t remember the recipe

5. You should take lots of time to make this dessert properly. (F)

   Text reference  timing has to be exact, have to bake it right after making it

   correct: supposed to make it fast, if you take too long the ice cream will melt

3. Growing Cranberries

   Score

Factual Questions:

1. What kind of soil is needed to grow cranberries?

   correct: moist, wet, swampy
2. What is the cranberry plant’s worst enemy?
   correct: caterpillars  
   partial: insects, bugs

3. How do the farmers keep the cranberry plants from freezing?
   correct: put them or keep them underwater  
            put them in water
   partial: put water on them  
            no credit: spray water on them

4. How does the special plough get the cranberries off the vines?
   correct: it knocks them off or verbs like  
            rips, breaks, swipes, pushes

5. When are the cranberries ready to be picked?
   correct: in late summer  

6. What do the farmers do to the fields before picking the berries?
   correct: flood them with (millions of litres of)  
            water
   partial: spray them with water

**Inferential Questions:**

1. How do chemicals help the young cranberry plants?

   Text reference: chemicals used for worst enemy - caterpillars
   
   correct: kill caterpillars  
   partial: keep the bugs off, kills bug, keeps enemies away
2. What colour are the flowers of cranberry plants?

Text reference: field turns a gorgeous shade of pink as buds bloom

Correct: pink

2

3. What does the field look like when the farmers gather the berries?

Text reference: field flooded with water just prior to gathering berries

Correct: covered with water

Correct: red berries floating in water

Partial: piles of berries, empty vines

No credit: swampy, all muddy

2 1 0

4. Which insects help with growing cranberries?

Text reference: bumble bees pollinate flowers

Correct: bees

2

5. What do cranberry farmers need a big supply of?

Text reference: farmers flood the fields with millions of litres of water and put the berries underwater to avoid frost

Correct: water

2

T/F Questions:

1. Cranberries take a long time to grow. (T)

Text reference: seeds planted in fall, grow over winter, buds in spring, pick in late summer

Correct: ref. to plant in fall, grow over winter, pick in late summer, reference to 2-3 seasons

2 2

2. There are many cranberry farms in southern Ontario. (F)

Text reference: cranberries are grown out west in B.C. in low lying swampy areas

Correct: they grow in B.C., or out west

2
3. You can pick cranberries just like you pick strawberries. (F)

   **Text reference** cranberries are gathered using a special plough to knock them off the vines

   correct: ref. to picking cranberries by machine and strawberries by hand 2

4. Farmers wear high rubber boots when they pick cranberries. (T)

   **Text reference** farmers push the plough through the flooded fields, implies that water is deep

   correct: ref. to field being all flooded with water 2

   partial: feet would get wet, all muddy, ref. to walking through swampy mud 1

5. You could grow cranberries in the mountains. (F)

   **Text reference** cranberries are grown in low-lying swampy field that are flooded with water during the process of gathering them

   correct: need low swampy fields, couldn't flood fields in the mountains (answer must refer to special growing conditions for cranberries) 2

   partial: too cold or too rocky 1

---

4. Electric Eels

**Factual Questions:**

1. What are the organs that work like batteries made out of?

   correct: muscles and nerves 2
2. How much electricity do eels produce?

correct: enough to light up 10 light bulbs at the same time

partial: a lot (not specific)

3. When does the eel send out an electric shock?

correct: when it senses something nearby when it feels something moving when it’s in danger, wants to defend itself

4. What does the electric shock do after it hits something?

correct: bounces back

partial: kills it or scares it away

5. What does the shock tell the eel?

correct: how far away and how big object is how far away and ref. to prey or enemies

partial: one of: how far or how big there’s something there in its territory

6. What part of the eel do the electric shocks come from?

correct: the tail

Inferential Questions:

1. How does the eel know something close by is dangerous?

   Text reference: shock bounces back and tells eel how big and how close object is

   correct: shock tells eel it is large (moving)

   partial: how far away it is
2. Why does the eel need electric shocks to find food?

**Text reference.** Electric eels are almost blind by the time they are adults

correct: It’s blind, can’t see its prey

3. Why would an electric eel stay near some rocks?

**Text reference.** Eel hides in rocks when shock tells it object is dangerous

correct: Hide from predators, enemies, larger fish

partial: Waiting for prey to swim by (logic)

4. What are the small moving objects the eel goes after?

**Text reference.** If moving objects are smaller than eel it thinks they are food

correct: (Small) fish

5. What would happen to the eel if its batteries stopped working?

**Text reference.** Batteries are the power source for the shocks which the eel uses to find food and defend itself

correct: Couldn’t find food - starve

or wouldn’t know when a predator was near - get killed

no credit: Answer implies the batteries are like a heart or central power source keeping the eel alive

**T/F Questions:**

1. Electric eels are always trying to attack other sea animals. (F)

**Text reference.** Shocks used for both defense and offense

correct: Sometimes trying to hide from predators; wouldn’t attack larger fish
2. Younger eels can see better than full-grown eels. (T)

_**Text reference**_ eels are nearly blind by the time they are adults; implies a progressive deterioration of vision

_correct:_ almost blind by the time they are adults

3. Eels can tell if moving objects are dangerous or not. (T)

_**Text reference**_ the shock tells them how big and how far away the moving object is

_correct:_ they tell by the shock - if it's a big object, it's dangerous (must mention both shock and big)

_partial:_ by the shock

4. Eels are afraid of smaller moving objects. (F)

_**Text reference**_ the eels go after smaller moving objects thinking they are food

_correct:_ they go after them; eat them the small ones can’t hurt them

_partial:_ the eels are bigger than them (logic)

5. People could tell if electric eels were in the water near them (T)

_**Text reference**_ the shock lights up the water

_correct:_ they could see a light; glow

_partial:_ they could feel a shock they could see the eel
Appendix C

Error Detection Tasks - Administration, Measures, and Scoring

Task 1 - Listening to Instructions

Instructions: “Lots of times kids have to listen to instructions about how to make something or how to make something work. You have to follow the instructions in the right order so that you can do the job properly. I have some instructions on tape that were written for kids, but some of them might have some mistakes in them, like things being in the wrong order. I need your help to act like a judge and decide if they make sense or not. Some of them might be OK and others might have steps in the wrong order.

After you listen I'll ask you if the instructions were in the right order. If you find a mistake the first time, we'll listen to different one, but if you don't hear anything wrong, you can listen again just to make sure. If something did not make sense, tell me which part and why it didn't make sense. Here is a practice one so you know what to do.”

Trial passage: Making a Pizza

To make a pizza, first you take a pizza crust and spread some pizza sauce all over it. Then you put whatever toppings you want on the pizza, like mushrooms, onions, or pepperoni. Some people like to put different kinds of toppings on different parts of the pizza. So, for example, you could have half the pizza with pepperoni and mushrooms and the other half with ham and pineapple. After you put the toppings on, you cut the pizza up into individual servings. Then you sprinkle mozzarella cheese all over it, and put it on a cookie sheet or pizza pan. Finally, bake it in a hot oven for about 15 minutes, being careful to not let it burn on the bottom.

If the child does not detect the error after listening to the trial passage twice, the error is demonstrated and explained. This is done only on the trial passage. The 4 test passages are then presented when the examiner is assured that the child understands the goal of the task. During the 4 test passages, if the child reports an error that is not a sequence error, his response is acknowledged, however he should then be redirected to listen again for instructions being in the wrong order.

Scoring:
- correct error identification receives a score of 2.
- responses that allude to the correct location of the error or the correct proposition, but do not specifically explain the error can receive a partial score of 1
- responses on error passages indicating that the instructions on error passages made sense receive a score of 0
- responses on the foil passages (i.e., no errors) indicating that the instructions made sense receive a score of 0 - foil passages are presented twice, same as error passages
Task 2 - Listening to Descriptions

Instructions: “When you are listening to somebody who is explaining something new, you have to listen hard and make sure you understand everything. Sometimes people make mistakes in what they say, and then it doesn’t make sense. I have some descriptions of things like animals and science topics that were written for kids your age, but I need to know if they all make sense. Some of the descriptions might be fine, and others might have mistakes in them, like one minute you hear one thing and then you hear something else that doesn’t make sense. Your job is to act like a judge and decide if everything makes sense or not.

After you listen I’ll ask you if everything made sense. If you find a mistake the first time, we’ll listen to different one, but if you don’t hear anything wrong, you can listen again just to make sure. If something did not make sense, tell me which part and why it didn’t make sense. Here is a practice one so you know what to do. It’s about how foxes learn to hunt when they are pups.”

Trial passage: Fox Pups

A young fox pup faces many difficulties in the wilderness. The mother fox usually has three or four pups to look after. When they first leave the den, they must watch out for predators like hawks and wolves. It is common for a mother fox to return to the den and find one of her pups is missing. Foxes learn how to hunt when they are quite young. Hunting is hardest in the winter because smaller animals like rabbits can easily see the fox’s reddish colour against the snow. Trappers are more dangerous to the young fox than any other wild animals. The trappers have a hard time spotting foxes with their white winter coats, but once their traps are set the young fox easily gets caught. The fox will fight hard to get away, but its fight is useless with the trap’s steel teeth buried deep in its paw. It will go crazy with pain and anger, and will try to lick its wounds to heal them, but it will probably die of hunger if it cannot get free. Only the strongest and luckiest pups will survive and grow to be adults.

If the child does not detect the error after listening to the trial passage twice, the error is demonstrated and explained. This is done only on the trial passage. The 4 test passages are then presented when the examiner is assured that the child understands the goal of the task. During the 4 test passages, if the child reports an error that is not a factual inconsistency (i.e. he is simply challenging one of the propositions in the passage), his response is acknowledged, however he should then be redirected to listen again for something that did not make sense.
Scoring:
- correct error identification receives a score of 2
- responses that allude to the correct location of the error or the correct proposition, but do not specifically explain the error can receive a partial score of 1
- responses on error passages indicating that the information made sense receive a score of 0
- responses on the foil passages (i.e., no errors) indicating that the information made sense receive a score of 1 - foil passages are presented twice, same as error passages
Error Detection Task 1 - Listening to Instructions

Changing a flat tire (error) (161 words)

It’s a good idea to know the steps in changing a flat tire because sooner or later it will probably happen to you or your family. If your tire goes flat while you are driving, the first thing to do is slow down and pull over to the side of the road. Make sure to put on your emergency brake so that your car doesn’t move while you change the tire. Then you have get the spare tire, tools, and jack out of the trunk. Next, you loosen the nuts on the wheel that has the flat tire, take out the bolts, and take the wheel off. After that, you jack up the car so it is up off the road. Then you put the spare tire on and tighten up the nuts. Finally, lower the jack so the wheel is back down on the road. Put away the tools and jack, and now you can get on your way again.

How to Use a Bank Machine (OK) (162 words)

Kids these days use bank machines just like adults to make deposits or get cash out of their bank accounts. First you need your own bank card, which you can get by filling out a form at the bank. When you want to use the machine, you put your card into a slot in the machine and enter your secret personal security code. After that, you push a button to choose whether you want to deposit money into your account or withdraw money out of your account. If you are taking cash out, you punch in the amount and then press OK. If you make a mistake, you have a chance to correct it and then press OK again. Then, after that, your cash appears through a different slot and then the machine gives you back your card. Finally, you get a receipt through another slot. It shows how much money you took out and how much is left in your account.

How to prepare a garden for spring planting (error) (161 words)

Every year, people have to work on their gardens to get them ready for planting seeds and flowers. First, you wait until all the frost is gone from the ground. Next, you rake up all the dead leaves, grass, and weeds from the year before, and dump them into the ditch or your compost pile. Then, spread your flower seeds around the garden or plant them in little rows, covering them carefully with soil. After that, you should break up the soil with a shovel, and turn it over so that air gets into it. Then, use a rake or a hoe to spread the soil around evenly and smoothly. Now you can also plant small potted flowers from the plant store like pansies and marigolds. Dig small holes and put some water in each hole. Finally, gently take the plants out of their little pots and put them in the holes, filling in the soil so they stand up straight.

How to change a light bulb (error) (159 words).

If the ceiling light in your room goes out in the middle of your homework, you should know how to change the light bulb yourself. First, find a chair or stool to stand on, and climb up to check the light bulb to see whether it is 60 or 100 watts. You will want to find one with the same power to replace it. Turn off the light switch and let the bulb cool down while you go and find a new bulb. Unscrew the old bulb and discard it in the garbage or glass recycling. Then, carefully test it with your finger to see if it is still hot. If it is too hot to touch, wait about 5 minutes and try again. Then, take the new one and gently screw it into the receptacle until you can’t turn it any more. Finally, check to make sure the new bulb works by turning the light switch back on.

The Newfoundland Pony (error) (194 words; 11 sentences)

Have you ever heard of a Newfoundland pony? It was a wild pony that used to roam the high rocky cliffs of Newfoundland about 200 years ago. Early settlers captured many of them to use as work animals because they had strong backs for pulling heavy loads. The ponies were valuable to the farmers because they could do a lot of labour and were strong and healthy. They were also quite gentle in nature and could be ridden safely by young children. There was only one problem the farmers had to be concerned about. The ponies had to be kept in their own special stables because they had bad tempers, and could become quite dangerous. Their main job was the hard work of pulling sleds, ploughing fields, and moving loads of rock off land that was being cleared for farms. Their thick coats helped them to stay warm and work through the bitter winds of winter. The ponies also had strong teeth and could even eat bark or twigs in winter, when there was not much vegetation. Nowadays, there are only a few Newfoundland ponies left, but they are protected in special government parks.

The First Paper (OK) (193 words; 11 sentences)

Have you ever heard of writing on sheepskin? Before people learned how to make paper from plants and trees, they wrote on a material called parchment. Parchment was made by stretching and scraping the skin of a sheep or calf until it was dry, thin, and flat. It was very tough and lasted for hundreds of years, unless it got wet. If that happened, it wouldn’t stay flat anymore and would curl back up into its original shape and get very hard and stiff. So, people had to be very careful to keep parchment in a dry place. Parchment was used for important writings from the church or for letters written between kings and important people. It was usually yellow in colour, but sometimes it was tinted with a purple dye so that silver and gold ink would show up clearly on it. Later on, people learned how to make parchment more white in colour, like our paper today. Making books out of parchment was a long and difficult job. Because each page was made out of animal skin, books were quite thick and heavy, even with only a few pages of parchment.

Jellyfish (192 words; 12 sentences)

You have probably heard about jellyfish, but actually, jellyfish are not really a kind of fish at all. Some people think they look like a floating bag of jelly, and others think they look like an umbrella with streamers. But jellyfish are just very strange ocean animals. Their bodies are made up of two layers of cells with water in between. They have no fins, scales, or bones, not even a head. They can move themselves easily through the ocean by shooting the water out from inside their bodies. Their skeletons are curved in shape and can bend easily. So, they can quickly move off in a different direction when their enemies are close by. The cells in the different parts of the jellyfish have different jobs, like cells for eating and cells for making eggs. There are lots of tentacles that hang down from the bottom layer of cells. These tentacles are covered with sharp stingers that paralyze the jellyfish’s prey by shooting poisons into them. The stingers can also be dangerous for swimmers, and can make people quite sick with pain and vomiting if they are stung by the tentacles.

Penguins (error) (194 words; 11 sentences)

Penguins are stout, short-legged birds that live in the colder oceans in the southern hemisphere. Most people are familiar with their black and white colouring that makes them look like funny-looking waiters wearing tuxedos. Although penguins have wings, they cannot use them for flying like most other birds. Penguins live mainly on fish, squid, and crabs that are found near the ocean surface. But every few years these animals become scarce, and the mother penguin has to fly long distances in search of a new food supply. These birds are great swimmers, and can dive deep under water in search of food. They move easily through the water using their wings like paddles and their webbed feet and tails to help them steer. Penguins live in large colonies and return year after year to the same place to breed. When they breed, each parent has an important role to play. The father penguin looks after the eggs for 2 months while the mother goes to sea to feed. When the eggs are ready to hatch, the mother returns to the breeding ground and then the father goes out to sea in search of food.

Appendix D

Listening Comprehension Passage Characteristics

1. Expository Passage Comprehension Task

<table>
<thead>
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<th>#words</th>
<th># sentences</th>
<th>average # words/sentence</th>
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<tbody>
<tr>
<td>Making Mummies</td>
<td>230</td>
<td>13</td>
<td>17.7</td>
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<tr>
<td>Baked Alaska</td>
<td>235</td>
<td>14</td>
<td>16.8</td>
</tr>
<tr>
<td>Growing Cranberries</td>
<td>237</td>
<td>13</td>
<td>18.2</td>
</tr>
<tr>
<td>Electric Eels</td>
<td>235</td>
<td>13</td>
<td>17.6</td>
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2. Error Detection Tasks

Listening to Instructions

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<tbody>
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<td>18</td>
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<td>How to Use a Bank Machine</td>
<td>161</td>
<td>9</td>
<td>17.9</td>
</tr>
<tr>
<td>Planting a Garden</td>
<td>159</td>
<td>9</td>
<td>18.3</td>
</tr>
<tr>
<td>How to Change a Light Bulb</td>
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<td>9</td>
<td>17.3</td>
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Listening to Descriptions

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<td>17.6</td>
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<td>Parchment</td>
<td>193</td>
<td>11</td>
<td>17.5</td>
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<tr>
<td>Penguins</td>
<td>197</td>
<td>11</td>
<td>17.9</td>
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Appendix E

Summary of Pilot Data for Listening Comprehension and Error Detection Measures

The trial and test passages for the listening comprehension and error detection tasks were administered to 10 normally achieving children and 7 children with difficulties with language, attention, and academic achievement. The age range of pilot participants matched the target age range for the study (9-12) with the exception of one child in the low achievement group who was 13 years 5 months. Pilot data are summarized below:

1. Listening Comprehension Passages

<table>
<thead>
<tr>
<th></th>
<th>Normals ( n = 10 )</th>
<th>LI/ADHD ( n = 7 )</th>
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<tbody>
<tr>
<td>Facts*</td>
<td>X 31.8 Range 22-40</td>
<td>X 17.5 Range 8-28</td>
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<tr>
<td>Inferences*</td>
<td>X 35.4 Range 30-38</td>
<td>X 28.5 Range 20-38</td>
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<tr>
<td>T/F</td>
<td>X*** 36.4 Range 30-40</td>
<td>X*** 26.6 Range 24-30</td>
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* Facts - maximum score 48  
** Inferences - maximum score 40  
*** based on 4 children

2. Error detection passages

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<th>LI/ADHD ( n = 7 )</th>
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<td>( n = 6 )</td>
<td>( n = 3 )</td>
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<table>
<thead>
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<th>Task 2</th>
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<tr>
<td>sequences</td>
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</tbody>
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* based on 6 normal children and 4 LI/ADHD children