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**Reading Words and Reading Minds:**

**An Investigation of the Skills of Children Diagnosed with Hyperlexia**

**Volume I**

**Lindy Rosen**

**Submitted for the Degree of: PhD**

**January 2001**

**City University**

**Department of Language and Communication Science**



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# VOLUME 1

FIGURE 7.5 a PAGE 174

FIGURE 7.5b PAGE 176

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First and foremost, I thank my supervisors Shula Chiat and Tim Pring for their never-ending wisdom, guidance and insights, for their enthusiastic interest in Hyperlexia, for their mentoring and encouragement and for inspiring my commitment to research, a commitment that undoubtedly will continue to influence my future work as a Speech Therapist.

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### Declaration:

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## **Abstract:**

**This study presents an investigation of the underlying linguistic profiles of ten Hyperlexic children and explores the nature of the problems which give rise to their diagnosis. The subjects' unexpected exceptional decoding strength together with their similarly unusual reading comprehension failure form the focus of this study. Reasons accounting for both these phenomena are explored. Diagnosis of these subjects is considered in relation to previous definitions of Hyperlexia and claims about its symptoms, nature and association with other deficits. An overview of the controversy and conceptual confusion regarding explanations of Hyperlexia is emphasized. The sources of the Hyperlexic symptoms observed in the subjects are explored and discussed in relation to current psycholinguistic models of reading and its development. This inquiry leads to two sets of investigations, the first focusing on the subjects' decoding skills and the second on their comprehension and inferencing abilities. The investigation explores a number of questions regarding the subjects' reading skills. These include determining whether the Hyperlexic subjects prefer one route to reading over another (use lexical or sublexical strategies), whether the deficit is modality specific, whether their unusual reading pattern is consistent over time, whether the subjects can access the semantic system and understand words they read as well as the manner in which they approach the learning of novel words (whether semantic cues help or hinder the learning of new words). Findings from the first set of questions leads to a further investigation of the subjects' comprehension failure. Word, sentence and paragraph level semantic and syntactic skills are explored and ruled out as primary sources of the comprehension breakdown. Instead, pragmatic language weaknesses are confirmed and a relationship is established between these symptoms and the comprehension failure. The notions of Relevance, Theory of Mind and Central Coherence are discussed and their application to Hyperlexia considered. The concluding discussion addresses a number of theoretical questions regarding the nature of Hyperlexia. Implications for intervention and possible future directions for research are proposed.**

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## **Chapter 1- Introducing the Subjects**

### **1.1 General Overview- an introduction**

The impetus for this research study stemmed from the identification of an unusual and distinct group of children attending a special education school for Learning Disabled (Learning Difficulties) students of an average to gifted intellectual capacity in Washington D.C., U.S.A. These students displayed a linguistic profile that contrasted with the majority of other students in this educational environment as well as those obtaining Speech and Language Therapy through an on site outpatient clinic.

Their language skills were marked by significant weakness in comprehending material that was read despite extremely strong abilities to read aloud written material. In contrast, the majority of children at this school exhibited good comprehension ability which they were unable to use when reading owing to decoding problems. Typically, this group received the diagnosis of Dyslexic while the afore mentioned group had been diagnosed as Hyperlexic and had received intervention with a therapeutic focus on their apparent reading comprehension breakdown. These students, though seeming to display language difficulties in informal and spontaneous situations did not necessarily manifest traditional language disorders on formal measures.

Their diagnosis of Hyperlexia raised concerns as to the need for defining more precisely the nature of this so-called phenomenon given that this group's profile appeared discrepant from those usually labeled as having Hyperlexia. (Cossu and Marshall 1986, Siegel 1984).

Later sections of this chapter will further investigate issues of diagnosis as they relate to this intriguing group of subjects. The existence of this group of subjects within a school in which most students are diagnosed with Dyslexia as per DSM IV criteria also raised concerns regarding the relationship between Dyslexia and Hyperlexia and possible reasons why in this particular group of individuals comprehension could be so poor in the context of superior reading rate and accuracy. Throughout the study it is constantly acknowledged that all individuals whether diagnosed as having Hyperlexia or Dyslexia exhibit a unique language profile with their own patterns of strengths and weaknesses. Nonetheless, it is possible to define these two groups by their sharply contrasting skills in decoding rate and accuracy as compared with their reading comprehension skills.

This chapter will begin by focusing on the most striking features of the Hyperlexic group's language strengths and weaknesses and proceed to describe case profiles in greater detail.

The chapter culminates in a discussion targeting diagnostic questions leading to an identification of a range of theoretical issues to be explored in this study.

The subjects provided the impetus for this research and a description of their unusual patterns of abilities consequently forms a natural starting point.

## 1.2 The most striking features of the Hyperlexic Group:

What makes the subjects in this group stand out as compared with other language impaired persons? When one meets the individual students in this group one is immediately struck by their friendly faces, warm smiles, yet somewhat odd demeanour.

This is the child in the special education classroom who volunteers to read aloud in class.

As he reads, nobody is able to follow along since his rate is too rapid for comfort. He reads accurately and precisely appearing cognizant of punctuation marks, yet his voice is fairly monotonous and too loud for the situation. At the end of the passage he appears puzzled when the teacher asks high-level comprehension questions about the text as though this task was both unexpected and foreign to him, as though it was designed simply to confuse and trick him. He is unable to glean full meaning from the text apart from the recall of more superficial facts. Nonetheless, reading is regarded as a strength by him. "I'm a good reader," he proudly says.

This is the child who says, "reading has always been easy for me," or "I learned to read by myself." These subjects are unusual in that their early reading development is reported to be unremarkable.

However, further discussion with their parents highlighted their ease in acquiring the decoding process as compared with their other linguistically driven skills.

This is the child who learned to read by watching “Sesame Street” on television, who seemed unusually interested in common signs and printed words. This is the child who appeared fascinated by letters at a young age, who enjoyed the act of reading and for whom reading seemed pleasurable.

This is also the child who today appears fairly adept in light, superficial social interactions. This child will easily meet and greet others although perhaps with slightly formal and/or rigid vocabulary choice. He will spontaneously wave to adults or peers from the bus as he arrives at school in the morning.

Nonetheless, this is also the child who grins enthusiastically even when the communicative situation doesn’t warrant it. He will yell “hi” from afar eager to engage in conversation, but then he will typically select repetitive conversational topics from a limited repertoire. This is also the child who misperceives more complex social situations, who is frequently confused by the rapid pace of spontaneous conversation, who adds inappropriate comments or mistimes his remark with consequent negative peer reaction. This child will neglect to understand and use subtleties common to regular conversations. He will laugh, but not understand the joke.

He will misunderstand sarcasm and interpret it as a compliment. He will use high level vocabulary in apparently meaningful contexts and later show that the word was not in fact understood.

The remedial implications of devising appropriate intervention plans for these children represents a unique challenge especially in light of their contrasting profiles as compared with other children in their educational environment. Detailed case history information follows.

### 1.3 A further introduction to the Hyperlexic group

The Hyperlexic group consisted of ten subjects, five of whom were full-time students at the Lab School of Washington at the onset of the study. The remaining five subjects were outpatients attending mainstream educational settings or receiving home schooling. Eight of the ten subjects were receiving weekly Speech and Language Therapy at the Lab School. All ten had been diagnosed as having Hyperlexia by prior professionals. Each subject's gestational period and birth history were normal.

Following a descriptive case history of each subject, the reader is referred to tables 1.3a and 1.3b for further documentation of selected common key linguistic features.

D.W. was thirteen years old at the start of the study. Developmental milestones were unremarkable with the exception of speech and language delay.

He was diagnosed with a developmental language disorder at age two and a half. D.W.'s language disorder was characterised by comprehension difficulties, poor pragmatic abilities, weaknesses following directions and a tendency to echo the sentences of others. He learned to read prior to attending formal education, and reading stood out as the easiest of skills for D.W. to acquire. He appeared fascinated by the printed word. D.W. has been at The Lab School of Washington, a special education environment, since the age of six. Those working with him today still describe him as an avid rapid reader although his reading comprehension is reported to be extremely poor and fragmented. In addition, D.W. continues to present with a range of pragmatic language difficulties including fleeting eye contact, monotonal speech and misunderstanding of word meanings, tone and gestures of speakers.

M. Dit. was ten years old when the study commenced. M. Dit's first word was "Watertown" from a Bruce Hornsby story, and his first sentence was a line from a Bruce Hornsby song. He was diagnosed with a mild language delay at age three. M. Dit. was able to use complex sentences, although he usually spoke in repetitive phrases and sentences, using situationally specific scripts to maintain conversation. His mother remarked that she was shocked when at age three and a half he began to spontaneously recall words on street signs and printed words in books or on the television. She noted that he was both fascinated and enthralled with the printed word and his enthusiasm to read was insatiable.

This skill was even more remarkable in the context of a child who always chose to play alone with little variety and novel play observed. Today, M.Dit still thrives on reading activities and appears unaware that he has not comprehended the information he has read. He reads in a monotone although at times he is able to vary his voice but then it sounds overly dramatic and inappropriate for the meaning of the passage. His Mother stated, "It's as if all the nuances of language need to be explained to him."

M.H. was thirteen years old when the study began. Developmental milestones were age appropriate. Nonetheless, at age seven, M.H. was diagnosed with a Developmental Language Disorder and Learning Disability. Some self-stimulatory behaviours including hand clapping and repetitive humming were noted at that time. Weaknesses in auditory processing, semantic organisation and social language skills were described. His parents were shocked that he was classified as Learning Disabled. "He even learned to read by himself," his Mom argued. Today, M.H. is a frustrated learner. Although he reads fluently and accurately, he is unable to discuss material he has read. He frequently selects irrelevant details to share. Several pragmatic language difficulties also remain evident in his profile. M.H. seldom introduces himself to others or expresses compliments and he displays a significantly delayed response pattern that negatively impacts conversation.

C.W. was ten years old when the study commenced. C.W.'s developmental milestones were all unremarkable. He was referred for Speech Therapy at age five because of an apparent inexplicable gap between superior skills in some areas e.g., he learned to read by age four, and weaker receptive and expressive oral language skills. A developmental language delay was diagnosed at that time characterised by weakness in word retrieval, syntax, pragmatics, language organisation, inferencing and a mild fluency disorder. He was reported to use questions excessively, not as a means of gathering information, but rather as a means of taking a conversational turn.

His parents noted his fascination with "Sesame Street" on television and how quickly and effortlessly he learned the alphabet and could read even before entering kindergarten.

Today, C.W. always volunteers to read in class. "I'm the best reader in my grade," he told me just the other day. His teachers state that while he does indeed read extremely fluently, he struggles to identify the main ideas in passages read and his explanation of stories jump divergently from topic to topic, frequently ignoring key salient features upon which the story is pivoted. While C.W. appears very friendly and sociable, he is not able to sustain lengthy relationships and is often confused about their ending as he is about passages he reads.

C.W. is the student who will look at a license plate on a car that says, "I like fishing" and is unable to infer what the person likes to do in his/her spare time.

W.H. was nine years old at the commencement of the study. Developmental milestones were normal except for delayed Speech and Language Development. W.H. was slower in starting to use expressive language and relied heavily on pointing or grunting to accomplish communicative goals. At age three and a half a diagnosis of Receptive and Expressive Language delay was made. Nonetheless W.H. learned to identify letters very early. He sought out reading experiences when at preschool and his favourite game was to rearrange magnetic letters to form words, a game he played alone.

Both W.H.'s younger siblings also present with significant language disorders. One of them is diagnosed as Dyslexic and the other with a diagnosis on the Autistic Continuum. Today, W.H. is no longer a student at The Lab School of Washington, although he continues to receive full time special education services. He reads in a newscaster tone, Frequently after reading a passage he will appear puzzled and bewildered and state, "I wonder what that was about," or " that's weird - it doesn't make any sense to me at all." Although he talks a lot W.H.'s topics wander and he makes loosely related points.

B.N. was nine years old when the study began. His developmental milestones were within normal limits. B.N. learned to read prior to beginning formal education. He loved repetitive activities such as, "The alphabet song", and although his Mom said that sounded 'mechanical' he could recite street and shop signs without prompting. He has an older sister diagnosed with Learning Disability.

Although B.N. was not attending The Lab School of Washington at the start of the study, he transferred to a special education environment from his mainstream school midway through the study. He was diagnosed with a Developmental Language Disorder and Learning Disability at the age of eight. B.N.'s language disorder was characterised by problems with auditory processing, pragmatics, memory and comprehension. Today, B.N. reads excessively rapidly. He frequently misunderstands homework assignments and struggles to complete book reports or successfully answer test questions involving reading comprehension. His teacher stated that he always nods his head in agreement and appears to understand the material only then to show that he was confused.

S.Q. was eleven years old when the study began. Once again developmental milestones were within normal limits. S.Q. was first evaluated by a Speech Therapist at the age of nine when a Developmental Language delay was diagnosed. His younger sister also shares the same diagnosis. S.Q.'s Mother reported that she thought S.Q. would be an exceptional reader. She said that he learned the alphabet and could read words by the age of four. Reading was automatic and effortless for him and it was only after he entered formal education that she realised that he was not understanding the material he read. Today, S.Q. attends a mainstream school. His class assignments need to be broken down step by step for him and he benefits from having his textbooks on tape so that he can listen to the auditory input while he reads.

E.J. was also eleven years old at the start of the study. She has a brother diagnosed with Dyslexia. E.J. was ten years old when she was diagnosed with a Developmental Language delay. Her language difficulties were characterised by weak organisation of language, poor memory, auditory processing difficulties and pragmatic language problems. Her parents commented that they were unperturbed about her early language learning skills. She even learned to read by the age of five and required limited formal education to master the decoding process.

She was always very quiet and it was only after formal academic demands increased that those around her started to recognise the extent of her reading comprehension difficulties. Today E.J.'s reading comprehension weaknesses impact her daily functioning in several ways. She is the student who constantly smiles gently when asked a question, but then can only provide a range of tangential information. She is the student who says, "I don't get it," after reading a story.

E.G. was fourteen when the study began. Her developmental milestones were unremarkable. She was referred for Speech and Language therapy at age seven and was diagnosed with both an Articulation Disorder and a Language delay at that time. She was also diagnosed as Learning Disabled and has attended The Lab School of Washington ever since.

Language weaknesses were noted to involve weak semantics, pragmatics and processing skills. E.G.'s parent commented that she learned to read easily, but that she never appeared interested in the meaning of the reading process, but rather in the mechanics of reading itself. Today E.G. requires much adult support for reading tasks that have accompanying comprehension activities. She will delight in informing you that she has read all the books on her 11th grade reading list, but will be unable to discuss any of them in detail.

The final subject is A.H., who was fifteen years old when the study began. A.H. attends a mainstream school. He was diagnosed with a Developmental Language Delay and Learning Disability at the age of eleven. He learned to read without difficulty and his parents commented that they were delighted that reading appeared so easy for him when he was in preschool. It was only when he started school that they became aware that he could not adequately comprehend the material he could read. Today, A.H. says, "It seems as though my eyes pass over the words and at the end of the page I have no clue what I've read." He misunderstands the salient features of instructions that he reads and frequently completes entire assignments only to find out that he misunderstood the direction. A.H. is the subject who produces complex verbal formulation with advanced vocabulary only to ask a few minutes later, "What did my sentence mean?" He will interject comments such as, "Can I get bonus points for using complicated words?" when it is clear that he has not used them appropriately.

These ten subjects present with many common features. Most striking are their reading developmental histories and their pervasive and longstanding reading symptoms. Striking too, are their pragmatic language difficulties. These issues are documented in tables 1.3a and 1.3b in order to avoid repetition and redundancy and to serve as a further exemplification of the key symptoms shared by the subjects.

Information in table 1.3a stems from case notes, parental accounts and current observations of the children.

Table 1.3a - Reading Development and Symptoms

| Feature:                                                    | Names: |          |    |    |    |    |    |    |    |    |
|-------------------------------------------------------------|--------|----------|----|----|----|----|----|----|----|----|
|                                                             | dw     | m<br>dit | mh | cw | wh | bn | sq | ej | eg | ah |
| learned to read by age 5                                    |        | +        |    | +  | +  | +  | +  | +  |    |    |
| learned to read without or with<br>minimal formal education | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| fascinated with letters                                     | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| reading comprehension<br>unexpectedly poor                  | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| reading rate excessively rapid                              | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| very accurate reading                                       | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| reads in a monotone                                         | +      | +        | +  |    | +  | +  |    |    |    |    |

Table 1.3b is based on observations of children in both school and therapy sessions as well as from reports of formal testing of comprehension.

Table 1.3b - Pragmatic Symptoms

| Symptom:                                                     | Names: |          |    |    |    |    |    |    |    |    |
|--------------------------------------------------------------|--------|----------|----|----|----|----|----|----|----|----|
|                                                              | dw     | m<br>dit | mh | cw | wh | bn | sq | ej | eg | ah |
| voice too loud/soft/<br>rapid/high                           | +      | +        | +  | +  | +  |    |    | +  | +  | +  |
| poor comprehension of<br>humour                              | +      |          | +  | +  |    | +  |    | +  | +  | +  |
| overly formal                                                | +      | +        |    |    | +  |    | +  |    | +  |    |
| misunderstands tone, gestures                                | +      |          | +  |    | +  | +  | +  | +  | +  | +  |
| poor comprehension of<br>figurative and abstract<br>language | +      | +        | +  | +  | +  | +  | +  | +  | +  | +  |
| eye contact poor                                             | +      | +        | +  |    | +  | +  |    | +  | +  | +  |
| repeats jingles and<br>commercials                           |        | +        |    |    |    |    |    |    |    |    |
| poor topic development                                       | +      | +        | +  | +  |    | +  | +  | +  | +  | +  |
| inappropriate facial expression                              | +      | +        | +  |    | +  |    |    | +  |    |    |
| poor timing of remarks                                       | +      |          | +  | +  | +  | +  |    |    | +  |    |

Both tables are self explanatory in their illustration of similarities amongst subjects. A review of their developmental histories points to other factors of interest including the fact that they all share normal gestational and birth histories and that those in special education environments were diagnosed with language disorders at a far earlier age than those attending mainstream environments.

A review of their developmental histories also indicates that while all of the subjects were diagnosed with Hyperlexia none received a diagnosis of Semantic-Pragmatic Disorder, Autism or Dyslexia despite their evidently abnormal language and reading abilities.

Diagnostic questions will be discussed further in the forthcoming section of this Chapter and later detailed standardised testing of the subjects will illustrate their problems.

#### **1.4 Diagnosis Challenged !**

In reviewing the case histories of the ten subjects one is struck by their unusual reading development as well as their semantic-pragmatic symptoms. While all ten subjects were diagnosed with Hyperlexia and this diagnosis was repeatedly confirmed by professionals, none were diagnosed as ever having a Semantic-Pragmatic Disorder or falling on the Autistic continuum or with any form of Developmental Dyslexia.

Clearly the reason that Hyperlexia or the reading component of these student profiles has been targeted by professionals is because it stands out so strongly and uniformly amongst them, that it is natural for professionals to address that area specifically. Certainly individual histories point to perseverative, repetitive, ritualistic behaviours not incongruent with features on the Autistic continuum, (Cobrinik 1974; Healy and Aram 1986; Frith and Snowling 1983; Whitehouse and Harris 1984) nor necessarily indicative of them, and indeed several past researchers have linked Hyperlexia to individuals with Autism and to children diagnosed with both Hyperlexia and Autism whose reading appears to be a savant skill (Cobrinik 1974; Goldberg 1987). Nevertheless, a review of the literature (See Chapter two) will show that Hyperlexia is neither a required feature of Autism nor is Autism a required concomitant factor in Hyperlexia. Chapter Two will discuss this notion further , and will also target an exploration of the relationship between Hyperlexia and Dyslexia.

What is most perplexing however, is the fact that professionals have not selected the Semantic-Pragmatic Diagnosis for these subjects (Bishop and Adams 1989; Brook and Bowler 1992). Perhaps this is because their semantic-pragmatic features are more subtle than their overt and rather bizarre reading patterns.

Perhaps it is because the diagnostic label of Semantic-Pragmatic Disorder is not as widely used in the United States as it is in the United Kingdom. Perhaps it is because their language profiles historically did not only involve semantic-pragmatic features, thus directing Speech Therapists to diagnose Mixed Receptive Expressive Language Disorders instead. Perhaps it is because Speech Therapists considered their semantic-pragmatic symptoms either as a consequence of Hyperlexia or even unrelated to it and simply one part of a wider developmental language delay.

Quite clearly the subjects do present with many symptoms congruent with Semantic-Pragmatic Disorder. Many have very fluent expressive language and employ utterances that are syntactically well-formed and phonologically intact. Many struggle to encode meaning relevant to the situation, are unable to successfully engage in communicative discourse and frequently provide irrelevant responses. Many were reported to echo what was said to them when young.

How helpful is a label? Would having a co-existing diagnosis of Semantic-Pragmatic Disorder account for Hyperlexia or explain it? Studies do not suggest that Hyperlexia is a necessary feature of Semantic-Pragmatic Disorder (Rapin and Allen 1987).

To the contrary, the literature has few studies that investigate reading skill in semantic-pragmatic disordered children, and only one that speaks specifically of the relationship between Semantic-Pragmatic Disorder and Hyperlexia (Cohen, Gelardo and Campbell 1987).

This thesis is not about labeling or debating whether ten children should have received one primary diagnosis or the other. It is about ten children who present with unique and fascinating reading profiles as well as unusual and complex pragmatic language difficulties, that may or may not be related to each other. This thesis is about exploring and better understanding each of these factors in order to better serve this population of individuals whose reading and language skills are poorly explained and appropriate remediation for them little understood.

### 1.5 Emerging Theoretical Questions

Let's begin by looking at the subjects reading symptoms. A range of theoretical questions emerge. These questions centre around two predominant themes. The first relates to the subjects' unexpectedly advanced and unusual reading fluency and accuracy. The nature of the decoding strength is a prominent focus of this study. After an initial literature review, information processing models are considered in terms of possible explanations of accounts of Hyperlexia.

The thesis poses a number of research questions related to the decoding success associated with Hyperlexia. These questions include determining how the subjects with Hyperlexia embark upon the reading process, and whether they prefer one reading route to another (lexical versus sublexical strategies). Other research questions in this area involve identifying whether the deficit is modality specific, and the consistency of the reading pattern of subjects with Hyperlexia over time. In addition, this study addresses questions regarding the manner in which subjects with Hyperlexia approach the learning of novel words, the impact of semantic referents on the learning process, and whether these subjects are able to access the semantics of complex words they decode. Finally, questions will be raised regarding the nature of reading rate and accuracy in a task devoid of reading comprehension demands. One of the central themes of this thesis, the question of whether the decoding abilities of the children with Hyperlexia are truly supranormal, will be addressed through answering the above set of questions.

The other major theme explored in this study is the second prong of Hyperlexia, the comprehension breakdown. As the thesis unfolds, a number of research questions related to this theme will evolve.

These include determining whether oral language deficits at the word or sentence level could account for the comprehension failure, and identifying whether the comprehension problems are isolated to reading tasks or are also evident in auditory comprehension activities.

Exploring the nature of the pragmatic language difficulty of subjects with Hyperlexia and whether the observed pragmatic weaknesses impact reading comprehension will also be studied.

Finally, this thesis will question the nature of deficits in social cognition, their manifestation in pragmatic language symptoms and their association with reading comprehension breakdown. The study will pose questions relating to the concepts of Relevance, Theory of Mind and Central Coherence and will explore a potential link between the comprehension failure of the children with Hyperlexia, their co-existing pragmatic deficits and their decoding abilities.

## Chapter 2 - The enigma of Hyperlexia

### 2.1 Hyperlexia - a definition

For the purpose of this study, Hyperlexia is defined as the co-occurrence of both surprising decoding success and unexpected reading comprehension failure. In agreement with Snowling and Frith (1986), for a subject to be considered as having Hyperlexia, they must show signs of both the decoding success and the comprehension failure and cannot demonstrate one feature at the exclusion of the other. Although this view is in direct contrast to Temple and Carney's (1996) study, it represents the most widely accepted definition of Hyperlexia. Temple and Carney found that Hyperlexia (advanced decoding) need not co-occur with comprehension difficulties, but rather it seemed to represent a genuine hyper-development of a skill in children with Turner's Syndrome. Albeit an interesting perspective, it does not reflect the focus of this study.

Early and/or spontaneous acquisition of reading skill is frequently observed in those with Hyperlexia (Burd, Kerbeshian 1985; Mehegan and Dreifuss 1972; Healy, Aram, Horwitz and Kessler 1982) and this population may or may not present with accompanying linguistic weaknesses. Although this definition is not criterion based, it best explains the essential factors required for a diagnosis of Hyperlexia and will be used throughout this study.

## **2.2 Conceptual Confusion**

### **2.2.1 Past definitions**

Historically, the literature has been fraught with confusion regarding the definition and identification of subjects with Hyperlexia. Initial definitions were flawed because of their overinclusive nature which resulted in a failure to adequately differentiate subjects with Hyperlexia and normal readers with strong decoding skills. This presumably was a consequence of the fact that the term was not used to reflect reading disability but rather to alert educators that they should not necessarily expect a level of reading achievement that matches decoding ability.

In fact Silberberg and Silberberg (1967), the first researchers to use the term Hyperlexia, used it simply to refer to children whose decoding skill was out of proportion to their comprehension ability. While they used criteria to define unexpected decoding success (therefore a child's reading level had to be 1.5 years above expected word recognition level in grades 1 and 2 and 2.0 years above that level in grades 3 and older), they did not address the comprehension failure in similar terms.

The resulting confusion is exemplified in Niensted's (1968) study in which originally twenty-six of forty-eight children tested were diagnosed with Hyperlexia.

She then addressed the improvement of their reading comprehension skills via in-service training of teachers. She proposed that when comprehension lessons were added to the regular classroom curriculum, only one of the ten children with Hyperlexia who were retested continued to be diagnosed with Hyperlexia. Subsequent definitions have varied in terms of their focus. The majority of definitions have targeted a spontaneous and early interest in letters and words. (Mehegan and Dreifuss 1972; Huttenlocher and Huttenlocher 1973; Richman and Kitchell 1981; Cobrinik 1982; Needleman 1982; Healy, Aram, Horwitz and Kessler 1982; Goldberg 1987 and Pennington, Johnson and Welsh 1987). Many of these definitions have emphasised the driven, compulsive, indiscriminate quality (Needleman 1982) or the obsessive-compulsive ritual of reading (Huttenlocher and Huttenlocher 1973).

Several definitions have also incorporated mention of a comparison of reading skill with cognitive and linguistic abilities and most authors have concluded that word recognition skills are significantly higher than that expected based on cognitive or linguistic levels. (Mehegan and Dreifuss 1972; Richman and Kitchell 1981; Cobrinik 1982; Healy et al 1982; Needleman 1982; Goldberg 1987 and Kistner, Robbins and Haskett 1988).

Nonetheless, the definitions have also proved perplexing because although they may share certain similarities they also have been used to refer to subjects with wide ranging cognitive skill and deficit levels (Cossu and Marshall 1986; Pennington et al 1987).

Some authors have focused exclusively on the reading skill itself, and likened Hyperlexia to a form of Developmental Dyslexia. (De Hirsch 1971; Benton 1978; Healy and Aram 1986). Thomson's (1984) definition of Developmental Dyslexia will be employed for the purpose of this study. Accordingly, Developmental Dyslexia refers to a severe difficulty with the written form of language, independent of intellectual, cultural and emotional causation.

Dyslexia is characterised by the individual's reading, writing and spelling attainments being well below the level expected, based on intelligence and chronological age. This difficulty is a cognitive one affecting those language skills associated with the written form, particularly visual-to-verbal coding, short term memory, order perception and sequencing.

DSM IV states that the child with a reading disorder (Dyslexia) produces oral reading that is characterised by distortions, substitutions or omissions. Clearly the individual with Hyperlexia could not be classified with Developmental Dyslexia using the definition cited above, and this study will further explore this distinction by comparing and contrasting the Hyperlexic group with a group of subjects meeting Thomson's criteria for Developmental Dyslexia. Although Hyperlexic reading is in sharp contrast with Developmental Dyslexia, it may have some similarity with the acquired form of Dyslexia referred to as Direct Dyslexia or non-semantic reading. (Newcombe and Marshall 1985; Lytton and Brust 1989).

A review of the definitions of Hyperlexia highlights the confusion in the literature regarding clear criteria for its identification. This confusion relates to the difficulty researchers have had defining the concept of Hyperlexia itself.

### 2.2.2 Who then can be Hyperlexic ?

If Hyperlexia can be applied to some normal readers merely because they read well and if it can be observed in subjects displaying wide ranging skill and deficit levels, it becomes difficult to define precisely who should be identified as having Hyperlexia. It is not surprising therefore that Pennington et al (1987) identified Hyperlexia in a preschool male with a superior IQ who read at a level beyond that predicted for his age. He was reported to have had an IQ of 144 and, at the age of 2 years 11 months could read 24 of 30 nonwords presented. Could this child truly be diagnosed with Hyperlexia or was he simply an advanced reader? This case is in contrast to most studies today that regard Hyperlexia as a pathological condition which has other associated deficits. (Richman and Kitchell 1981; Cobrinik 1982; Healy 1982; Needleman 1982; Cossu and Marshall 1986; Goldberg 1987). Hyperlexia appears most noticeable in extreme cases when the discrepancy between reading achievement in terms of reading fluency and accuracy, is so significant as compared with cognitive and/or linguistic abilities and concurrent comprehension skills are extremely limited (Cossu and Marshall 1986).

It raises the argument as to whether Hyperlexia is linked with the causation of the associated deficit, or equally plausibly, whether it could be an independently random event manifested in such a way, that, the more disabled the individual, the greater the mismatch between skills and the more overt the Hyperlexia. It is useful for us to consider the associated deficits in more detail in order to address this issue.

### 2.2.3 Associated Deficits

Although there are several deficits and factors that have been associated with Hyperlexia, the literature is indecisive regarding the relationship between these associated deficits and Hyperlexia itself.

One of the most commonly associated deficits is that of Autism. Many studies have suggested a relationship between Hyperlexia and Autism, and several have identified Hyperlexic symptoms in Autistic individuals. (Huttenlocher and Huttenlocher 1973; Cobrinik 1974; Richman and Kitchell 1981; Fontenelle and Alarcon 1982; Frith and Snowling 1983; Aram, Rose and Horwitz 1984; Whitehouse and Harris 1984; Siegel, 1984; Burd and Kerbeshian 1985; Snowling and Frith 1986; Kistner, Robbins and Haskett 1988; and Tirosh and Canby 1993).

Nonetheless, the literature remains perplexing regarding the precise nature of the relationship between the two conditions. On the one hand there is ample evidence to suggest that Hyperlexic symptoms can be found in some individuals with Autism. On the other hand, there is no indication that Hyperlexia is a necessary feature of Autism, nor is there sufficient evidence to indicate the prevalence of Hyperlexia in subjects with Autism. Studies exploring the potential for a common neuropathological basis for the two conditions can only be described as preliminary at best and warrant further investigation. (Tirosh and Canby 1993).

Several researchers who have studied Hyperlexia in individuals with Autism (Mehegan and Dreifuss 1972; Elliot and Needleman 1976; and Aram, Rose and Horwitz 1984), and have searched for an explanation linking the two conditions by viewing Hyperlexia as an isolated, savant-like skill. This forms a logical corollary, as other savant skills such as musical ability, drawing and calendrical calculation have frequently been associated with the Autistic population.

Accordingly, subjects with superior decoding ability could be regarded as possessing an isolated precocious reading ability (savant skill) that develops without specific instruction and that appears disassociated from other areas including reading comprehension.

Hyperlexia could then reflect a truly modular ability to decode words accurately and automatically without accessing the semantic system. Nevertheless, the argument is complicated by the fact that research has shown that some subjects with Hyperlexia can access the semantic system (Frith and Snowling 1983). This suggests that although decoding could be a modular skill, it can be less isolated in certain cases. This indicates that it can exist alongside varying levels of other abilities and is much more easily reported when other abilities are low or absent. Additionally, Goldberg (1987) suggests that the majority of children with Hyperlexia over the age of ten do not read better or more than their peers, so that their reading skill appears less savant-like at a later reading age. This feature certainly distinguishes children with Hyperlexia from other savant-like abilities, but the fact that normal readers catch up with them does not exclude Hyperlexia from being a savant skill.

A review of the literature reveals that the conceptual confusion does not rest there, but extends to other associated deficits. In particular, there is great variation in the cognitive levels of subjects identified with Hyperlexia. These subjects have been shown to vary both in terms of full scale composite scores (Fontenelle and Alarcon 1982; Frith and Snowling 1983 and Whitehouse and Harris 1984 ) with some inconsistencies in verbal/performance discrepancies noted as well (Whitehouse and Harris 1984; Richman and Kitchell 1981; Cohen, Campbell and Gelardo 1987).

Overall, the majority of studies conducted with individuals with Hyperlexia have included subjects who have had full scale IQ scores that have fallen below that expected for their chronological age. Many of these subjects have exhibited moderately to severely deficient cognitive scores prompting certain authors to recommend that Hyperlexia be limited to individuals with scores in this range (Siegel 1994). However, Hyperlexic symptoms have been identified in subjects with normal cognitive abilities (Richman and Kitchell 1981) as well as in a subject with superior cognitive potential (Pennington et al 1987), leading one to conclude that Hyperlexia is not necessarily related to restricted cognitive ranges.

The literature also points to a trend indicating that performance IQs of subjects with Hyperlexia are significantly stronger than verbal IQs, particularly for higher IQ subjects. (Richman and Kitchell 1981; Whitehouse and Harris 1984). The performance /verbal discrepancy is however less remarkable and in some instances insignificant for lower ability subjects (Healy et al 1982; Cossu and Marshall 1986). Nonetheless, several authors have been prompted to use nonverbal or performance IQ scores in place of verbal or full scale scores (Snowling and Frith 1986; Pennington et al 1987). The generally stronger performance score of subjects with Hyperlexia may reflect an underlying linguistic weakness compromising their verbal IQs or equally plausibly could point to strength in visual perceptual abilities contributing to or resulting in their exceptional decoding success.

Hyperlexia has in fact been associated with a number of deficits in the acquisition of language skills (Healy, Aram, Horwitz and Kessler 1982; Cohen et al 1987; Richman and Kitchell 1981).

In general, studies have suggested that individuals with Hyperlexia have weaknesses comprehending and integrating language, difficulties categorising and organising information in a meaningful fashion, and weak processing of language. Only one study has proposed a connection between Hyperlexia and Semantic-Pragmatic Disorder, however. Cohen et al (1987) described their subjects with Hyperlexia as exhibiting a variant of Semantic-Pragmatic Disorder with profound deficits in their ability to comprehend spoken as well as written language thereby warranting a classification as Language Disordered.

Their subjects displayed relatively greater impairment in receptive as compared with expressive language development although expressive language skills were also impaired. They had difficulty processing connected speech. Although their spontaneous language was fluent, their conversational language was often paraphasic or tangential in nature. This tangential quality was regarded as secondary to their comprehension disorder.

In contrast, other studies have documented Hyperlexia in the context of normal language development (Pennington et al 1987).

Temple and Carney (1996) further supported the disassociation of Hyperlexia from generalised language disorder. Nonetheless, they appeared to base their opinions on data from verbal IQS and verbal comprehension subtest scores rather than from in-depth or comprehensive language assessments.

The literature becomes increasingly baffling when one considers the nature of the given associated deficits carefully. For example, researchers have failed to distinguish whether the language weaknesses documented in subjects with Autism and Hyperlexia are a reflection of their autistic features or of a linguistic deficit related to Hyperlexia. The inconclusivity in the literature has added to the complexity of the conceptual confusion.

Given the vast variation in associated deficits and the heterogeneity of those diagnosed with Hyperlexia, it seems increasingly plausible that Hyperlexia could be an independently random event.

An additional issue that could shed further light on this notion is the consideration of genetic and/or familial trends as they relate to Hyperlexia. Selected studies have investigated this issue. (Healy and Aram 1986; Healy, Aram, Horwitz and Kessler 1982).

Although they suggest that the disorder could be genetically transmitted, because eleven of the twelve children they studied were males with paternal histories of language learning problems, limited alternate data exists to substantiate this finding. While Hyperlexia has been identified in a preponderance of males, it has also been found in females (Elliot and Needleman 1976). It is proposed that the genetic and/or familial trends will only be clarified once the conceptual confusion related to Hyperlexia is resolved.

Theories advanced to account for Hyperlexia in terms of neurologic dysfunction have been equally inconsistent. Findings have ranged from the documentation of neurological soft signs (Mehegan and Dreifuss 1972) to overt seizure disorders (Cobrinik 1974; Cossu and Marshall 1986; Burd and Kerbeshian 1985) and to completely negative results (Pennington et al 1987). Other studies have proposed specific sites of lesion including parietal lobe involvement (Huttenlocher and Huttenlocher 1973), while others have claimed that, since some individuals with Hyperlexia improve over time, specific neurologic lesions are unlikely (McClure and Hynd 1983). Neurologic explanations are therefore as inconclusive and unsatisfactory as other accounts of associated deficits.

The following table (table 2.2.3 ) provides an illustrative but not exhaustive summary of the associated deficits and conceptual confusion rampant throughout the literature.

**Table 2.2.3 Associated Deficits and Conceptual Confusion**

| <b>STUDY</b>                              | <b>COGNITION</b>                                          | <b>ASSOCIATED DEFICITS</b>                                                                                               |
|-------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>Burd and Kerbeshian (1985)</b>         | mental retardation                                        | hypergraphia, poor socialisation, speech and language delay                                                              |
| <b>Burd, Kerbeshian and Fisher (1985)</b> | mental retardation                                        | PDD, Autism, Developmental Language Disorder                                                                             |
| <b>Cobrinik (1974)</b>                    | ranged from<br><br>borderline to the<br><br>40's or below | Autism, emotional withdrawal,<br><br>profound linguistic and psychological<br><br>deficits, deviant behaviour, echolalia |
| <b>Cobrinik (1982)</b>                    | 42-70<br><br>mean :50.2                                   | social withdrawal, birth abnormalities,<br><br>Childhood Schizophrenia, Autism,<br><br>Psychosis of early onset          |
| <b>Cohen et al (1987)</b>                 | 76-100<br><br>nonverbal IQ test                           | Speech and Language Delay, Attention<br><br>Deficit Disorder, Hemiparesis, possible<br><br>seizure disorder              |
| <b>Cossu and Marshall (1986)</b>          | 53-56                                                     | morphologic and syntactic disturbances                                                                                   |

Table 2.2.3 (continued)

| STUDY                                   | COGNITION                                      | ASSOCIATED DEFICITS                                                                                                                                    |
|-----------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Elliot and Needleman (1976)             | formal testing not possible                    | repeated otitis media, respiratory distress at birth, hyperactive, compulsive behaviors, abnormal EEG, apraxia of speech- absence of expressive speech |
| Fontenelle and Alarcon (1982)           | 57-118                                         | maladaptive behaviors, attention deficits, deficient socialization, very poor language abilities, ritualistic behaviors, echolalia                     |
| Goldberg and Rothermel (1984)           | in general: non-verbal IQ stronger than verbal | language delays, weaknesses relating to others                                                                                                         |
| Healy and Aram (1986)                   |                                                | Autistic-like behaviors, lack of symbolic play, poor language                                                                                          |
| Healy, Aram, Horwitz and Kessler (1982) |                                                | disordered language                                                                                                                                    |
| Frith and Snowling (1983)               | 54-103                                         | Autism, language deficits, obsessional phenomena                                                                                                       |

Table 2.2.3 (continued)

| STUDY                                  | COGNITION                                                        | ASSOCIATED DEFICITS                                                                                                                        |
|----------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Kistner, Robbins and Haskett<br>(1988) | 48-87 full scale                                                 | language and social development<br>problems                                                                                                |
| Mehegan and Dreifuss (1972)            | moderate to<br>severely retarded<br>range (11 of 12<br>subjects) | abnormal language development, limited<br>spontaneous speech, echolalia,<br>inconsistent birth histories, invariably<br>abnormal neurology |
| Pennington Johnson and Welsh<br>(1987) | 144                                                              | normal language and social development,<br>uncomplicated birth and developmental<br>milestones                                             |
| Richman and Kitchell (1981)            | 92-104                                                           | language delay, hyperactivity, learning<br>disability                                                                                      |
| Snowling and Frith (1986)              | mean of 78                                                       | Autism                                                                                                                                     |
| Temple and Carney (1996)               | 78-117                                                           | Turner's Syndrome                                                                                                                          |
| Whitehouse and Harris (1984)           | ranged from<br>severely to<br>profoundly retarded<br>to gifted   | Autism, Language Delay, Hypergraphia,<br>Hyperlalia                                                                                        |

### **2.3 Hyperlexia - a starting point**

The discussion thus far has focused on the conceptual confusion in the literature specifically as it relates to defining Hyperlexia itself as well as its associated deficits. Although it is reasonable to propose that this area is too baffling and the research too fraught with apparent contradictions limiting the usefulness of one's conclusions, it is equally plausible to view these conceptual issues as extremely exciting and worthy of further exploration.

The reader is referred back to the original definition of Hyperlexia to be used in this study. Accordingly, a subject is considered to have Hyperlexia only if he/she exhibits unexpected decoding success together with surprising comprehension failure. It is neither possible to determine whether Hyperlexia should be linked with the causation of the associated deficits or viewed as an independently random event, nor is it possible to truly understand what gives rise to this decoding/comprehension mismatch based on the past research studies. What the literature and the conceptual confusion does lead us to question is how reading skills are acquired. This in turn leads us to reflect upon models of the reading process culminating in questions as to how disorders like Hyperlexia can relate to such models.

## Chapter 3 - Cognitive Neuropsychology and Hyperlexia

### 3.1 An Introduction

This chapter describes models of reading and reading development in order to place Hyperlexia in the context of what is known about reading and its development, adopting a cognitive neuropsychological perspective. The chapter will explain the cognitive neuropsychological approach, it will outline a model of normal reading and illustrate how this model has been used to explain the patterns of reading seen as a result of acquired neurological damage. Some of these patterns share similarities with Hyperlexia. The chapter will also examine models of reading development and look at how these explain Developmental Dyslexia. Finally, the chapter will summarise what the cognitive perspective can offer for the study of Hyperlexia.

### 3.2 What is Cognitive Neuropsychology?

Ellis and Young (1988) suggest that cognitive neuropsychology represents a convergence of cognitive psychology and neuropsychology. They define cognitive psychology as the study of those mental processes which underlie and make possible our everyday ability to recognise familiar objects and people, to find our way around the world, to speak, read and write, to plan and execute actions, to think, make decisions and remember.

In contrast, neuropsychology refers to the study of how particular brain structures and processes mediate behaviour. The study of neuropsychology dates back to the late 19th century with research by Broca, Wernicke, Lichtheim and Hughlings Jackson. These researchers emphasised associations between anatomical sites and clinical findings suggesting that damage to particular brain regions resulted in distinct manifestations of symptoms clusters such as aphasia.

Bradshaw and Mattingley (1995) emphasised that these early studies focused on assigning complex functions to a specific brain lesion and it was only with Hughlings Jackson's work that the notion of localising a lesion and localising a function became conceptually distinct. Bradshaw and Mattingley contrast Neuropsychology with the related yet distinct disciplines of Neuropsychiatry and Behavioural Neurology. They emphasise that Neuropsychology is concerned with elucidating the mechanisms underlying abnormal and normal behaviour and that modern Neuropsychology is based not only on data from brain-damaged individuals, but also from the normal population.

They suggest, similar to Ellis and Young (1988), that Neuropsychology can be divided into subspecialities of Clinical and Cognitive Neuropsychology.

Accordingly, the former area focuses on explaining how specific patterns of disordered behaviour may arise from disruption of particular brain processes, while the latter discipline targets the explanation of disordered behaviour in terms of a disruption to particular information processing units with far less concern for the anatomical and physiological bases for the behaviour.

Clinical Neuropsychology can then be summarised as being anatomically based, reliant on the study of groups of patients with broadly similar sites of damage and relating these sites of damage to similar patterns of behavioural deficits. Clinical Neuropsychology is very much concerned with assessment and treatment. Nonetheless, when patterns of deficit arise the approach is rather limited in explaining these, as not only can they be varied in their manifestations but there is also no existing theory to explain how the brain carries out different behaviours and complex mental functions like language and memory.

Parkin (1996) suggests that Cognitive Neuropsychology is based on the principle that one of the easiest ways to understand how a system works is to observe what happens when it goes wrong. Accordingly, by recording and analysing the errors that emerge in a system one can determine how its components are organised and how they function.

He then suggests that the discipline of Cognitive Neuropsychology allows us to obtain greater insight into how the brain carries out mental operation based on observations of people with specific deficits following brain damage. Temple (1997) adds that Cognitive Neuropsychology deals with the subcomponents that comprise a skill and how a process is successfully achieved.

In developmental terms, it explores whether there is a single developmental pathway or multiple parallel routes to accomplish certain cognitive tasks. As such, Cognitive Neuropsychology focuses on the use of cognitive models to explain how we are able to accomplish specific cognitive tasks such as reading, memory and language. Individual cases are then explored relative to the model in order to determine whether the resulting patterns of deficit are consistent with the theoretical model. The models themselves are conceptual in nature rather than anatomical. This is helpful for conditions such as Developmental Dyslexia and Hyperlexia where no specific site of lesion has been identified.

Adult Cognitive Neuropsychology builds models on the basis of disorders seen following functional lesions to pre-existing systems while developmental Cognitive Neuropsychology builds models on the basis of disorders reflecting functional lesions to developmental systems.

Nonetheless, Temple (1997) proposes that both acquired and developmental Cognitive Neuropsychology focus on expanding models of normal function to construct a single model of a cognitive domain that can be explained in all cases.

Use of cognitive models therefore allows one to determine patterns of impaired and intact performance seen in brain-damaged individuals.

This has necessitated the establishment of cognitive models that can explain both associations and disassociations of functions. Disassociations are noted to occur when a person can complete task 1 but fails task 2. A disassociation must exist between the two tasks suggesting that they are handled by different sets of cognitive processes, so that one set may be impaired while the other functions normally. Particularly strong evidence is provided by double disassociations where patient A performs significantly better on task 1 than on task 2 and patient B presents with the opposite profile.

Accordingly, the cognitive neuropsychological perspective assumes that cognitive processes are organised into distinct cognitive entities or modules. Ellis and Young (1988) suggest that mental life is made possible by the orchestrated activity of multiple cognitive processes or modules.

As one set of modules can be responsible for one aspect of action and another for a different aspect, independent functioning of different modules occurs, even if the two modules come into direct contact. As such, brain-damaged individuals can process information effectively in one module but unsuccessfully in another. Fodor's (1983) Modularity Hypothesis has been used to explain how different components of a model can be autonomous and function normally while other components are impaired.

Parkin (1996) discusses the specific properties that the Modularity Hypothesis incorporates. These include that the modules carry out operations in isolation from what is going on elsewhere in the model, that each module can only process one type of input, that they function in an all-or-none fashion and that they are innate and are not acquired through development.

Parkin suggests that although some of these claims are highly controversial, the two most important to cognitive neuropsychology: information encapsulation (that modules carry out their operations in isolation from what is going on elsewhere) and domain specificity (that they can only process one type of information) are the least controversial.

Fodor's definition of modules is not strictly followed by current cognitive neuropsychological models, however the Modularity Hypothesis has made an important contribution to the field of Cognitive Neuropsychology.

One of the major contributions of the models of functioning approach include that they allow us to understand selective deficits, where one skill has failed to develop or has become impaired while other skills have developed (or in the case of adults with acquired disorders) have remained normal.

While cognitive neuropsychology is often regarded as more theoretical than traditional neuropsychology, treatment approaches have resulted from this theoretical perspective especially in the areas of dyslexia and dysphasia. Parkin (1996) adds that most recently neuropsychologists have also explored connectionist networks as a means of stimulating normal and impaired brain function and neuroimaging techniques have also become increasingly important in neuropsychology as they are able to shed light on functional relationships within the brain.

The cognitive neuropsychological perspective offers us a unique opportunity to better understand Hyperlexia and hence is focused on in this study.

Our understanding of Hyperlexia is enhanced through use of this approach as a result of a number of factors including that Cognitive Neuropsychology has long been used to explore reading disorders. (Marshall and Newcombe 1973, Coltheart, Patterson and Marshall 1987, Howard and Franklin 1987, Castles and Coltheart 1993, Howard and Best 1996). In addition, Cognitive Neuropsychology requires a modular approach and Hyperlexia must surely be a modular condition in that certain skills appear to be exceptionally well developed, while others have not developed adequately. Furthermore, Hyperlexia is not yet associated with any specific site of lesion so that classical neuropsychological models that are anatomically based cannot be used to explain the symptom cluster.

As Cognitive Neuropsychology is heavily dependent on careful observation of specific deficits within individuals and because it deals with complex mental functions and specific patterns of association and disassociation , it seems most relevant to the study of Hyperlexia. As such, the chapter will now explore models of reading from a cognitive neuropsychological perspective.

### **3.3 Models of Single-Word Reading**

**Models of single-word reading have been developed in order to better understand the complex variety of cognitive processes that are available to fluent adult readers for the pronunciation of print.**

**The models that have emerged have been based upon the different theorists' views regarding the possible routes to reading.**

**Many have suggested a dual-route model of reading aloud (Coltheart 1978). According to this viewpoint, skilled readers use at least two separate procedures when reading. One of these procedures is referred to as the "lexical procedure" and the other as the "sublexical procedure". The lexical procedure involves retrieval of the phonological form appropriate to a particular orthographic stimulus from a mental lexicon.**

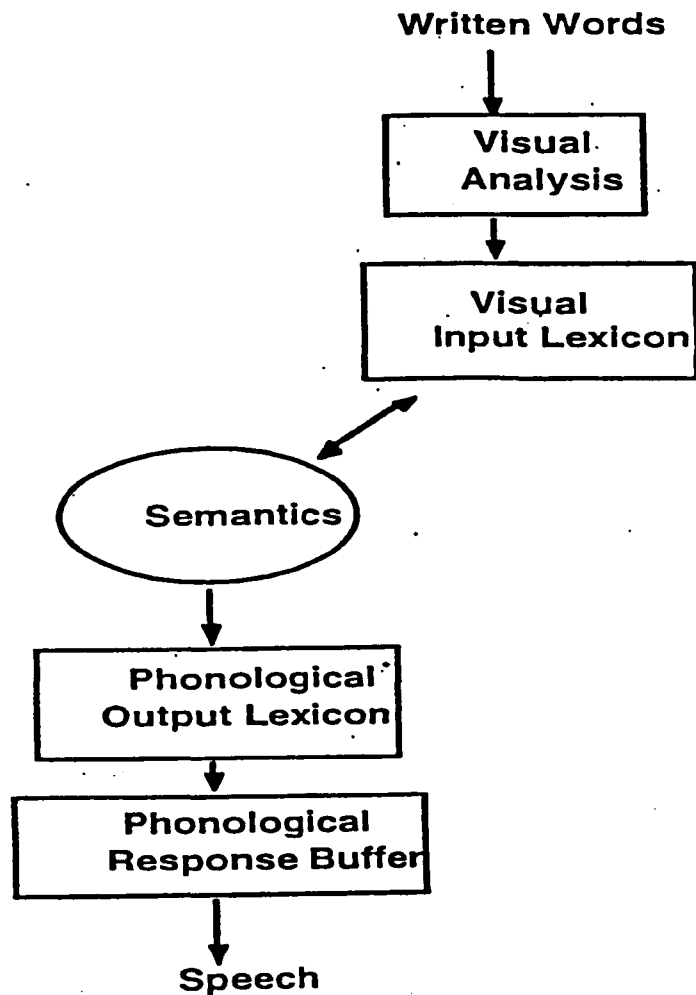
**Castles and Coltheart (1993) propose that the mental lexicon contains only representations of real words which the reader has encountered previously. In this way, the lexical procedure cannot be used to read non words as they do not exist in the mental lexicon.**

Instead, the sublexical procedure has to be employed using grapheme-phoneme correspondence rules which enable pronunciations to be assembled. The sublexical route can be used to read regular real words, but does not enable the reader to decode irregular or exception words so that skilled readers must be able to use both the lexical and sublexical procedure to decode accurately and fluently.

Ellis and Young (1988) suggest that two routes make up the lexical procedure and a third route forms the non-lexical procedure. Accordingly, the lexical procedure comprises the semantic and direct routes and the sublexical procedure comprises the phonological route. The semantic route involves activation of the visual input lexicon. Parkin (1996) suggests that many thousands of words are represented in this store and that the store does not contain information about the meaning of the words, but includes only that which pertains to the letter patterns of known words. Activation of the visual input lexicon in turn activates the semantic system so that words that are read can be understood. The word's spoken form is then activated, the phonemes retrieved and the word produced.

Figure 3.3 illustrates the semantic route.

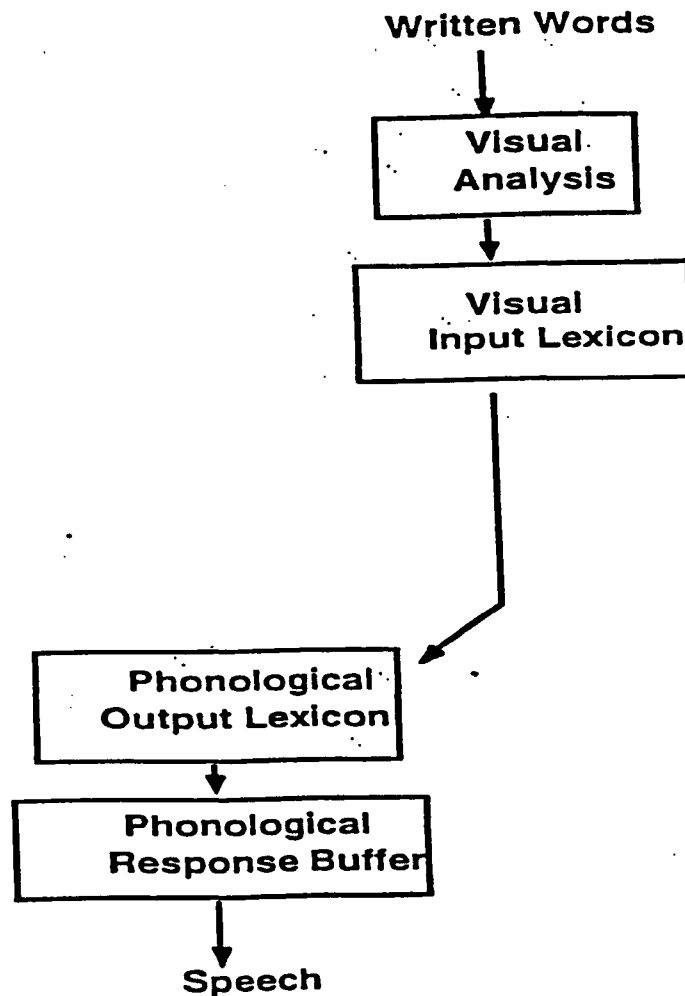
Figure 3.3.a The Semantic Route



A second route, the direct lexical route, allows access from the visual input lexicon directly to the speech output lexicon and bypasses the semantic system.

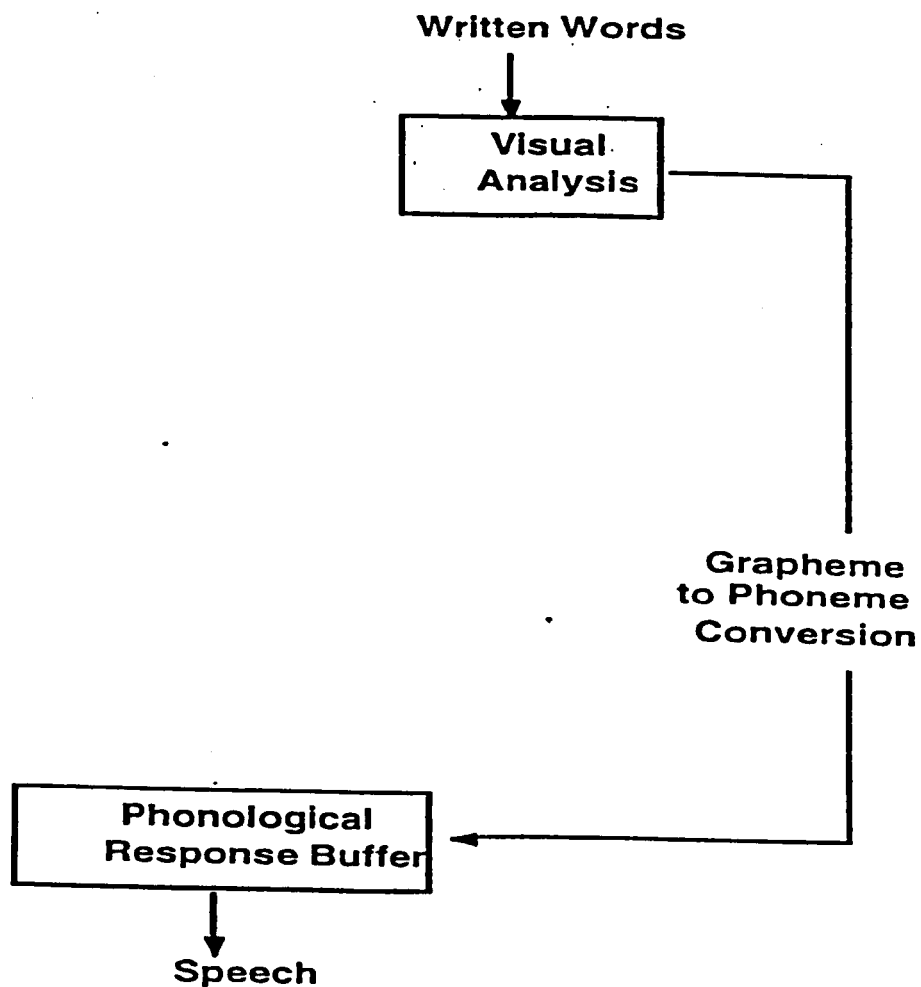
Figure 3.3b illustrates the direct lexical route.

Figure 3.3.b The Direct Lexical Route



The third route is the nonlexical or phonological route that goes directly from the written word to the phoneme level via grapheme-phoneme conversion. Parkin suggest that the grapheme to phoneme correspondence rules are not word specific but constitute our internalised knowledge of the principles of English pronunciation which we can apply both to words we know and to those that are unfamiliar. Figure 3.3.c illustrates the phonological route.

Figure 3.3.c The Phonological/ Sublexical Route



In order to better understand the contribution of each route to the single-word reading process, it is important to consider the role each plays and why each is necessary for the skilled decoder. Symptom patterns of acquired dyslexia verify the existence of these different routes.

The phonological route is essential for the decoding of unfamiliar words or non words. The fact that readers are able to decode a word like 'festooneeb' suggests that their phonological route is intact as the word can only be successfully decoded via accessing of grapheme-phoneme correspondence rules. Reading via the phonological route results in a regularity effect in English because exclusive use of the phonological strategy would result in irregular words being 'regularised' ( Parkin, 1996). If the phonological route is damaged the individual becomes unable to decode non words as the phoneme-grapheme correspondence strategy is not available. This can also be referred to as a deficit in the sublexical route.

Reading via either the direct or the semantic route allows us to decode real words but not non words. The semantic route is essential for us to understand the words we read, and it is usually accessed visually rather than phonologically. Proof of this can be found in subjects with Deep or Phonological Dyslexia who cannot read non words suggesting breakdown in the nonlexical (phonological) route.

Individuals with Deep Dyslexia have been found to understand written words by accessing semantics directly, and if they are able to read them aloud they do this by accessing the phonological output lexicon.

Further proof can be found from normal readers who have to rely upon a visual approach to understand the different meanings of homophones ( Howard and Franklin, 1987).

Nonetheless, Patterson (1982) suggests that lexical access based on a phonological code may be a strategic option under certain conditions. She differentiates addressed (postlexical) phonology from assembled (prelexical) phonology in her discussion of the above. In doing so, she notes that in reading aloud, once the printed word is recognised, its pronunciation can be addressed or looked up in a phonological lexicon indicating that addressed phonology is retrieved subsequent to word recognition. She compared this with prelexical or assembled phonology which is concerned with the nature of the code used to achieve word recognition.

Damage to the lexical procedure would be expected to result in over reliance on the sublexical or grapheme-phoneme conversion route. This form of acquired dyslexia was originally described by Marshall and Newcombe (1973) and is referred to as Surface Dyslexia.

Parkin (1996) suggests that in Surface Dyslexia a deficit may exist at some point between the visual lexicon and the semantic system.

Individuals with Surface Dyslexia typically can read regular words and non words, but they often produce regularisation errors, incorrectly using traditional grapheme-phoneme correspondence rules to decode irregular words. (Castles and Coltheart 1993; Bub, Cancelliere and Kertesz 1985; Coltheart, Masterson, Byng, Prior and Riddolph 1983). The failure to use word specific information by those with Surface Dyslexia also results in errors of stress (Coltheart et al 1983).

Kay and Patterson (1985) add that in Surface Dyslexia the communication between lexical orthography and semantic descriptions is lacking so that phonological influences upon reading comprehension are evident e.g. in confusion of homophones in which those with Surface Dyslexia successfully pronounce homophones with irregular spelling - sound correspondence despite incorrectly defining them. They give the example of “bury” being defined as a fruit on a tree. Subjects with Surface Dyslexia are thus reported to understand words they read only by reading the word out loud, so that semantics are only accessed via the auditory input lexicon. Parkin (1996) therefore suggests that individuals with Surface Dyslexia understand words as they read them aloud.

Nonetheless, there are subjects with Surface Dyslexia who do understand words they read aloud incorrectly (Kay and Patterson 1985; Howard and Franklin 1987) suggesting that they are reading sublexically, but also have access to the direct route. More recently, a further form of Surface Dyslexia has been discovered indicating that subjects can access semantics by the lexical route, but do not access the phonological output lexicon. Consequently they still read aloud by the nonlexical route and make regularisation errors, but can understand the words they read.

Therefore, although the damage in Surface Dyslexia is frequently considered to occur at an early stage of the visual route, selected authors have suggested that qualitative differences amongst patients exist. Howard and Franklin (1987) proposed three different routines available for written word comprehension and contrasted two subjects with Surface Dyslexia. The one subject relied exclusively on direct lexical access and could not phonologically recode for semantic access while the other relied mainly on phonological recoding via sublexical strategies. Kay and Patterson (1985) also stress that there are a number of ways that particular symptoms can be produced. These findings illustrate that the Dyslexia syndromes overlap questioning the validity of still using some of the original names. Nonetheless, the symptom patterns can still be explained by available models.

In contrast to Surface Dyslexia, both Deep and Phonological Dyslexia involve a deficit in grapheme-phoneme conversion resulting in a failure to read non words. (Funnell 1983; Howard and Best 1996; Snowling, Hulme and Goulandris 1994; Campbell and Butterworth 1985).

Marshall and Newcombe (1980) and Coltheart (1987) provide an historical perspective on Deep Dyslexia, a disorder incorporating a highly complex set of symptoms. In Deep Dyslexia damage must occur to the lexical and nonlexical routes resulting in effects on non word reading and problems with phonology forcing reading aloud to occur via the semantic route. As the semantic route is however also damaged, semantic errors result. High imagery words are read more accurately than low imagery words. Other symptoms include the production of visual errors in reading aloud, function words substitutions and derivational and inflectional errors.

In contrast Castles and Coltheart (1993) define Phonological Dyslexia as reflecting exclusive damage to the sublexical procedure for reading aloud. Subjects with Phonological Dyslexia are able to use either the semantic or the direct lexical routes.

There is support for a relationship between Deep and Phonological Dyslexia in reports that when those with Deep Dyslexia improve they read in a manner not dissimilar from individuals with Phonological Dyslexia (Job and Sartori 1984; Glosser and Friedman 1990).

In addition to reading via the phonological or the semantic route, there is also evidence that single-word reading can occur via the direct lexical route. Schwartz, Saffran and Marin (1980) discussed the reading ability of a subject with dementia who could read words aloud well despite not being able to understand them. The subjects' ability to read non words provided evidence for her use of the nonlexical route. However, since she could also read irregular words accurately she was not totally reliant on the nonlexical route suggesting the existence of the direct lexical route as well.

Similarly, Funnell (1983) described a subject whose semantic judgements about written words were significantly impaired relative to the subject's ability to read the words aloud. This subject could also not read non words. She concluded that this disassociation supported the view that 2 independent lexical routes are available for reading aloud familiar words - a semantic route and a lexical phonological route. Lytton and Brust (1989) also documented a subject with Direct Dyslexia verifying that it is possible to read words without comprehension.

Although the studies cited reflect acquired disorders and Hyperlexia is viewed as a developmental disorder their contributions to our understanding of Hyperlexia are extremely valuable. These studies demonstrate that reading aloud without comprehension is possible. If models of skilled reading allow for reading to break down because of damage to the semantic system or to its access then it is also possible that this may occur in reading development. It may be that subjects with Hyperlexia use either grapheme-phoneme conversion or the direct lexical route or both to read. If they rely on grapheme-phoneme conversion one might expect to see a regularity effect, but if they rely on the direct lexical route they would fail to read non words. In either case (or in cases who can use both) it should be possible to access meaning via the Auditory Input Lexicon. The fact that this access is not established suggests that semantics is poorly developed or inaccessible.

In very extreme cases of Hyperlexia one can propose that where reading far exceeds understanding, other reading routes must be able to develop in the absence of semantic information, in turn, suggesting modularity of functioning. This leads one to consider theories of reading development and how they may apply to Hyperlexia.

### 3.4 Theories of Reading Development

Castles and Coltheart (1993) suggest that acquiring a *skilled reading system* and then losing a component as a result of brain damage or insult may be somewhat different from never having acquired the system at all. They postulate that a completely different theoretical framework may be necessary for developmental reading disorders. However, they add that learning to read must involve the acquisition of the dual-route system because skilled reading requires both the lexical and sublexical procedure. As such, developmental reading disorders may indicate a specific difficulty in the acquisition of one or the other or both of these reading strategies so that similarities may exist in the symptom clusters of Acquired and Developmental Dyslexia.

It therefore becomes essential to understand how children learn to read so that developmental reading disorders can be viewed in the appropriate context.

Several researchers have suggested that children pass through specified phases while learning to read. (Frith 1985; Marsh, Friedman, Welch and Desberg 1981; Seymour and Mc Gregor 1984).

Frith (1985) proposed that there are three phases that children pass through in learning to become skilled readers. Skills acquired in each phase are built upon in the subsequent phase. Accordingly, Frith's first phase is referred to as The Logographic Phase. During this time children are reported to acquire a small sight word vocabulary which they learn to recognise automatically. Children utilise salient graphic features for word recognition and phonology is regarded as secondary, so that the child only pronounces the word once it is recognised. Castles and Coltheart (1993) suggest that as the number of words to be learned increases, use of the salient graphic feature strategy becomes progressively less effective as too many words share visual similarity. At this stage the child will be unable to respond to unfamiliar words presented in isolation and will rely upon contextual cues to guess unfamiliar words in context. Referring to Ellis and Young's (1988) model, the logographic phase corresponds to a very early and crude visual input lexicon without grapheme-phoneme conversion ability.

Frith's (1985) second phase is the Alphabetic Phase when children acquire the ability to use grapheme-phoneme correspondence when attempting to read words. Castles and Coltheart (1993) propose that this phase is comparable with the operation of the sublexical procedure, although the words are not necessarily pronounced correctly. This phase corresponds with Ellis and Young's grapheme-phoneme conversion route.

Frith's final phase is the Orthographic Phase during which time children learn to read words as orthographic units, without phonological conversion. Castles and Coltheart (1993) contrast this phase with the Logographic Phase and stress that the Orthographic Phase involves a recognition process that is not purely visual or cue based, but depends upon rapid recognition of internally represented abstract letter-by-letter strings. They liken this phase to the operation of the lexical procedure and they suggest that as children learn to read they do acquire the dual-route system of lexical and sublexical procedures.

Share (1995) suggests that there are a number of mechanisms that are useful in building an orthographic lexicon. While these include direct instruction, contextual guessing and phonological recoding, he demonstrated that it is only phonological recoding that offers a viable means for printed word learning.

Share proposes a self teaching hypothesis whereby each successful decoding experience with an unfamiliar word provides an opportunity to acquire the word-specific orthographic information which forms the foundation of skilled word recognition. He states that a relatively small number of successful exposures are adequate for the acquisition of orthographic representations both for skilled adult readers and young children.

Accordingly, he advocates that phonological recoding acts as a self teaching mechanism that enables the child to develop both word specific and general orthographic knowledge.

Share adopts an item-based rather than a stage-based perspective arguing that the process of word recognition depends primarily on the frequency with which a child has been exposed to a particular word together with the nature and success of item identification. Accordingly, high frequency words are likely to be recognised visually with minimal phonological processing, because of frequent exposure to the orthographic form, while novel and less familiar words, for which the child has yet to acquire orthographic representations, will be more dependent on phonology. Share therefore suggests that the incidence of phonological recoding will vary depending on the distribution of item familiarities. He concludes that the contribution of visual/orthographic factors to the acquisition of fluent word recognition must be secondary and not equivalent to phonology. Orthographic factors therefore result primarily from successful decoding.

Share is not alone in debating the phase based nature of reading acquisition theories.

Temple (1997) suggests that if all children must pass through stages sequentially then it is logical to assume that a child with a developmental disorder would have to be seen as delayed in acquiring the relevant skill.

In fact, Frith (1985) does propose that subjects with Developmental Dyslexia get stuck at either the alphabetic or orthographic phase. Accordingly, a child who cannot progress through the alphabetic phase may be able to recognise a restricted list of sight words, but would not be able to successfully decode novel words or non words. In contrast, the child who cannot progress through the orthographic phase can read words aloud as long as they conform with grapheme-phoneme conversion rules. However, this child cannot read irregular words not acquired during the logographic phase. In this way, the former subject may be likened to a subject with Phonological Dyslexia while the latter subject may appear similar to an individual with Acquired Surface Dyslexia.

Although this may be a compelling argument, not all children with Developmental Disorders are delayed and several children display deviant or different developmental patterns.

Hyperlexia, frequently identified as a hyper development of skill (Temple and Carney 1996) may be a case in point.

Stuart and Coltheart (1988) argue that individual differences exist in patterns of acquisition of reading skill. They identify children who are skilled phonologically and who use these strategies from the start without going through a logographic phase.

They do not claim that all children use phonological skills from the start but rather that children use whatever strategy is available to them when learning a new skill. While Frith (1985) believes that Dyslexia represents a failure to progress from one stage of the model to the next she does recognise that reading age may continue to increase through use of those skills that may remain.

Castles and Coltheart (1993) suggest that it is likely that a child with developmental dyslexia will have acquired both the lexical and the sublexical procedure to some degree, but that one process will be operating less efficiently than the other producing either a Surface or a Phonological Dyslexic pattern. They point out the importance of differentiating between a reading pattern which is abnormal because it reflects delayed skills as compared with one which is qualitatively different from that of younger normal readers.

Share (1995) predicted that Developmental Phonological Dyslexia would differ from that seen in adults as not only would non word reading be poor but word reading would also suffer because the child would not have appropriate opportunities to develop visual representations of words ( without opportunities for successful self teaching). In contrast, he predicted pure cases of Developmental Surface Dyslexia which would resemble Acquired Surface Dyslexia with an impairment in developing visual representations.

Holmes (1973) as cited by Castles and Coltheart (1993) was the first person to suggest a similarity between the symptoms evident in acquired dyslexia and those of developmental dyslexia. Several researchers have also considered the possible relationships between the two reading disorders.

Coltheart et al (1983) described a 17 year old girl whose reading performance resembled Acquired Surface Dyslexia in that she made regularisation errors. Goulandris and Snowling (1991) describe an adult, undergraduate university student with developmental dyslexia whose reading was normal on standardised tests but whose spelling had several phonological errors. Mild regularity effects and difficulty with homophones were evident.

In contrast to this pattern of errors, cases of Developmental Phonological Dyslexia have also been identified.

Temple and Marshall (1983) describe a patient who could read aloud both regular and irregular words but performed very poorly when reading non words and rare words. They concluded that she had a specific difficulty using the sublexical procedure and that her symptoms were analogous to Acquired Phonological Dyslexia.

Campbell and Butterworth (1985) also describe an undergraduate student whose reading and writing of real words was normal despite unusual difficulty reading and spelling non words. They found that she had difficulty accessing phonological representations of speech that she read or heard.

Snowling, Hulme and Goulandris (1994) studied a patient, J.M., and found that he failed to develop alphabetic competence and could not effectively apply grapheme-phoneme correspondence rules. Following Frith's (1985) model they suggested that J.M. should fail to become an orthographic reader and that he would remain a logographic reader using partial cues and accessing incomplete representations. However, they found no gross abnormalities within his word recognition system and he had developed a large number of words within his sight vocabulary in the presence of severely deficient sublexical reading processes. They therefore concluded that sublexical decoding strategies are not necessary for creating representations sufficient for sight word recognition. They added that although the absence of these reading strategies may delay the acquisition of word recognition devices it does not alter the nature or quality of these representations.

Accordingly, Snowling et al concluded that JM's case refutes the stage model theory. This study as well as that of Campbell and Butterworth (1985) also refutes Share's (1995) claim that those with Developmental Phonological Dyslexia should be so limited by their phonological breakdown that they would be unable to acquire orthographic representations. Studies by Howard and Best (1996) and Funnell and Davison (1989) also indicate that there are subjects whose word reading skills are adequate despite significantly poor non word reading. Nonetheless, Funnell and Davison's (1989) subject did have difficulty learning to read providing perhaps corroborative support for Share's viewpoint.

While a clear double disassociation exists between Surface and Phonological Dyslexic patterns, Howard and Best (1996) suggest that there are some subjects with developmental dyslexia who are poor at both non word and exception word reading thus indicating weaknesses in both the lexical and sublexical procedures. Castles and Coltheart (1993) stress that individuals with Dyslexia, whether they have the acquired or developmental forms, do not fall into homogeneous subgroups and that the same symptoms can be produced by problems with a number of different processes. Coltheart (1987) notes that the symptoms tell us how a person reads not why they are reading in that manner. Determining both why and how the individual reads are important.

Despite potential differences between developmental and acquired dyslexia, Coltheart advocates use of a single theoretical framework to explore both forms of the disorder because he suggests there is a specific set of skills that need to be acquired to become a skilled reader and the same set of skills are those that can be damaged in acquired dyslexia. The following section will discuss Hyperlexia as it relates to these disorders and to available theoretical frameworks.

### 3.5 Hyperlexia - A Cognitive Neuropsychological Perspective

This chapter has discussed cognitive neuropsychological perspectives to provide a framework for the exploration of Hyperlexia. The chapter began with an explanation of cognitive neuropsychological reading models and a discussion regarding acquired dyslexias and their relationship to the model. Stage theories of the normal developmental process involved in reading acquisition were also considered in order to provide a further context for an explanation of Developmental Dyslexia.

It was suggested that the cognitive neuropsychological perspective offers us unique opportunities to better understand Hyperlexia.

Not only has this perspective long been utilised in research on reading and reading disorders, but it also involves a modular approach, a perspective in keeping with current thoughts on Hyperlexia.

While there are limitations to the reading model approach, these limitations seem to be outweighed by the positive impact reading models can provide to expand our insight into disorders such as Hyperlexia. While it can be argued that Hyperlexia is a developmental disorder and should not be compared to an adult reading model it can equally be argued that a single theoretical framework can be used to discuss all reading disorders.

While it can also be argued that the available reading models illustrate the single-word reading process and Hyperlexia reflects a contextual reading disorder, the models themselves still provide a starting point from which to develop our understanding of Hyperlexia.

According to the reading model approach, reading aloud with or without comprehension can be accomplished using different pathways. This offers us the possibility of understanding the different forms of Acquired Dyslexia and to a lesser degree Developmental Dyslexia.

There are those that consider Hyperlexia a form of Dyslexia (Benton 1978, De Hirsh 1971).

Both the stage and the reading model approaches can help us understand the relationship between the two.

The reading model illustrates the various pathways available to the skilled reader. Reading via the direct lexical route indicates that it is possible to read accurately without comprehension.

If Hyperlexia truly involves reading without comprehension, then a possible link could exist between Hyperlexia and the forms of Acquired Dyslexia described by Schwartz et al (1980), Funnell (1983) and Lytton and Brust (1989) who documented subjects who could read words without being able to understand them.

While some studies have explored the relationship between Hyperlexia and Acquired Surface Dyslexia (Aram et al, 1984) there is no compelling support for such a relationship given the different symptom patterns found in the two disorders, the fact that subjects with Hyperlexia do not show regularity effects, as well as that one disorder is developmental and the other an acquired disorder.

A number of studies have pointed to the intactness of both the lexical and sublexical processes in Hyperlexia (Aram et al 1984; Frith and Snowling 1983; Goldberg and Rothemel 1984). This study will further explore the Hyperlexic group's ability to effectively use the lexical and sublexical procedures.

It will investigate the reading of nonwords by subjects with Hyperlexia to identify the competence of the grapheme-phoneme conversion/sublexical procedure. It will examine reading of irregular words to determine reliance on grapheme-phoneme conversion and will explore regularity, frequency and imageability effects.

The study will also target the investigation of the comprehension skills of subjects with Hyperlexia as some cases are reported with extremely poor comprehension while others suggest at least partial comprehension.

If the breakdown exists in the connection between the visual input lexicon and the semantic system one might expect auditory comprehension to be significantly better than reading comprehension. Huttenlocher and Huttenlocher (1973) explored this area and found equally poor performance on spoken and written comprehension implying that the breakdown is more likely to exist in the semantic system itself.

This, however, remains a feature that needs to be further explored to determine whether the breakdown exists in the semantic system itself or in its access.

Using the cognitive neuropsychological perspective, theorists are thus able to consider how Hyperlexia relates to the available reading models.

In so doing the reading models can be used to explain where the deficit in Hyperlexia may arise and which pathways individuals with Hyperlexia may use when approaching a single-word recognition task.

Theorists are also able to utilise the stage model approach and relate Hyperlexia to developmental models of reading acquisition. Seymour and Evans (1992) described a child with Hyperlexia who entered Frith's (1985) orthographic phase more rapidly than his peers but seemed to omit aspects of the alphabetic phase in that he did not sound out words like his peers. Nonetheless, his profile was clearly discrepant from individuals with pure Phonological Dyslexia who fail to develop the alphabetic strategy, as the reading of children with Hyperlexia is often regarded as supranormal (Temple and Carney 1996).

Howard and Franklin (1987) suggest that in Developmental Phonological Dyslexia, strong comprehension can develop, in the absence of, or despite, extremely weak phonological skills. Perhaps Hyperlexia represents the presence of strong phonological skills, in the absence of, or despite, extremely limited reading comprehension reflecting weaknesses in semantics. This study will explore available reading pathways in individuals with Hyperlexia to better understand the relationship between Hyperlexia and other reading disorders.

## **Chapter 4 Hyperlexia - A Beginning**

### **4.1 Background**

The literature on the reading and language skills of children with Hyperlexia raises fascinating questions about reading acquisition and models of the reading process. This chapter marks the beginning of the exploration of these issues for the subjects investigated in this study.

The ten subjects with Hyperlexia described in Chapter One represent the core group of subjects for this research project. The study begins by exploring the functioning of the children with Hyperlexia on a variety of standardised measures. These tools permitted all subjects to be compared with normative information appropriate and relevant to the population studied. As such, the children with Hyperlexia were compared with a normal control group on tests standardised on a United States sample. In addition, a comparison group of children with Dyslexia who were matched for age and gender was also used. This comparison group was selected because the literature suggests that Hyperlexia may be regarded as a form of Dyslexia (Benton, 1978; Aaron 1989). Equally plausibly, the two disorders may be viewed as mirror images of each other. The contrast in comprehension of written material is of particular interest. Here children with Dyslexia may show better abilities than those with Hyperlexia despite their handicap in decoding.

As a result, the children with Hyperlexia may be expected to be weak in precisely those areas expected to be strong in the children with Dyslexia.

The children with Dyslexia were selected from 500 children attending the Lab School of Washington Day School and/or outpatient programme. All five hundred case files and school records were carefully reviewed to aid the selection process. The subjects with Dyslexia were chosen for meeting the criteria of both Thomson's (1984) definition of Dyslexia and DSM IV criteria. Accordingly, a requirement of significant reading, spelling and written language difficulties (their scores on measures of reading, spelling and contextual written language fell at least two standard deviations below their cognitive potential) formed the criteria for entry into the study. All records pertaining to the subjects with Hyperlexia and Dyslexia were reviewed to determine that they all possessed at least average nonverbal cognitive potential, all spoke American English as their home and sole language, and all had normal hearing. In addition, the presence of a primary diagnosis of emotional disturbance, Autism or any other major health disability precluded participation in this study.

All the subjects diagnosed with either Hyperlexia or Dyslexia were receiving speech and language therapy at the Lab School of Washington when the study commenced.

The formal tests selected for this study were administered and scored in complete adherence with standardised procedures as presented in test manuals. Studies by Cobrinik (1974); Cohen et al (1987); Cossu and Marshall (1986); Fontenelle and Alarcon (1982) as well as Goldberg and Rothermel (1984) are amongst several that have employed standardised test administration in the exploration of Hyperlexia. Detailed descriptions of each measure are provided in Appendix A.

All subjects were evaluated in testing sessions of no longer than 2 hours. Testing was completed in a quiet, distraction-free environment (the Speech Therapist's office). All subjects were familiar with the examiner who had established good rapport with them prior to testing. Short breaks were provided between tests.

## **4.2 Formal Measures**

### **4.2.1 Nonverbal Intelligence**

As previous studies on Hyperlexia have included subjects varying dramatically in their cognitive potential it was important to identify the cognitive abilities of subjects investigated. Since linguistic weaknesses might influence verbal cognitive scores, nonverbal intellectual scores were employed as the indicator of intellectual functioning.

It was hypothesised that the children with Hyperlexia would exhibit average nonverbal intellectual functioning.

Although a review of the records pointed to the presence of at least average nonverbal intelligence in all subjects, it was decided that an additional measure of nonverbal intelligence should be conducted to verify this. The particular measure chosen, The Test of Nonverbal Intelligence 2 (TONI 2) was selected as a 'language free' normed task incorporating visual matrices. One sample Z tests were used to compare the Hyperlexic and Dyslexic groups with the norm. Table 4.2.1 presents the means, standard deviations, Z scores and levels of significance for the Hyperlexic and Dyslexic groups relative to the norm. The mean for the TONI-2 standardisation sample was 100 with a standard deviation of 15. The Hyperlexic group was not significantly different to the norm (one sample Z test:  $Z = 1.348$ ) although the table indicates that their score fell within the high to above average range. The Dyslexic group's scores were superior to the norm (one sample Z test :  $Z = 3.749$ ,  $p < 0.05$ ).

Table 4.2.1 -The Test of Nonverbal Intelligence (second edition):

| TEST   | MEAN               | SD                   | Z SCORE            | LEVEL OF<br>SIG.    | RANGE<br>OF<br>SCORES |
|--------|--------------------|----------------------|--------------------|---------------------|-----------------------|
| TONI-2 | H 106.4<br>D 117.8 | H 12.348<br>D 10.912 | H 1.348<br>D 3.749 | H -<br>D $p < 0.05$ | H 92-131<br>D 95-131  |

H = group with Hyperlexia

D = group with Dyslexia

An independent t test was used to compare the Hyperlexic and Dyslexic groups and showed that the subjects with Hyperlexia were significantly different to the subjects with Dyslexia at  $p < 0.05$  level ( $t = 2.140(18)$ ,  $p < 0.05$ ). Although the results pointed to a significant difference in the nonverbal cognitive abilities of the two groups it is important to note that this difference was due to an extremely high score in the Dyslexic group rather than a low score in the Hyperlexic group. This finding may relate to standard means of defining Dyslexia by exclusion which frequently favours high IQ children. Nonetheless, the results confirmed at least average nonverbal intelligence skills for both groups. The results also pointed to variability amongst both groups. As discussed above, although no subject displayed scores less than 0.5 standard deviation below the population mean, some scores fell as high as 2+ standard deviations above the population mean.

The subjects with Hyperlexia do however differ from many reported in the literature both in terms of age, and intellectual functioning (Cossu and Marshall 1986, Siegel 1984).

#### 4.2.2 Single Word Reading

Given the fact that the subjects were selected for their unusual reading abilities, it is most appropriate to begin the investigation by exploring their single word reading skills.

It was hypothesised that the Hyperlexic group would display significantly strong reading of single words, while the contrasting profile of significant weakness decoding single words would be evident in the Dyslexic group. The Slosson Oral Reading Test Revised, (SORT-R) a standardised test of single word reading was used to investigate this hypothesis. Table 4.2.2 illustrates the mean and standard deviations for both the Hyperlexic and Dyslexic groups on the SORT-R. The standardisation mean was 100 with a standard deviation of 16.

Table 4.2.2 - The Slosson Oral Reading Test-Revised:

| TEST   | MEAN    | SD       |
|--------|---------|----------|
| SORT-R | H 113.4 | H 6.022  |
|        | D 79.8  | D 12.577 |

H = Hyperlexic group

D = Dyslexic group

An independent t test showed a significant difference between the groups ( $t=7.62(18)$ ,  $p<0.001$ ), and indicates that the mean for the group with Dyslexia of 79.80 was significantly poorer than the mean for the group with Hyperlexia of 113.40. One sample Z test scores revealed that the Hyperlexic group's scores were significantly stronger than the norm (one sample Z score:  $Z = 2.823, p<0.01$ ), while the Dyslexic group performed significantly more poorly than the norm (one sample Z score:  $Z = 4.255, p<0.0001$ ).

This result is to be expected given the histories of the subjects and their known strengths and weaknesses in this area. The differences from the population mean are nevertheless substantial for both groups. Previous research may be unclear in many respects but does point specifically to this decoding strength as a hallmark of Hyperlexia. Several past researchers have verified this finding (Richman and Kitchell 1981; Cohen et al 1987), and the current results substantiate the Hyperlexic group's decoding strength. This result confirms the expected superior score for subjects with Hyperlexia. Further questions remain about their reading, however.

Previous studies (e.g., Cossu and Marshall 1986, Snowling and Frith 1986) have shown that decoding skills far exceed comprehension, necessitating the examination of this factor in the present subjects. The SORT-R does not tell us how the subjects achieve their strong score.

Are they reading normally or do they exhibit particularly strong phonological or visual recognition skills for words? This issue is of particular interest if it is the case that subjects with Hyperlexia can read words aloud at a level beyond their comprehension.

### 4.2.3 Word level Skills

#### a. Semantics

Previous studies have shown that subjects with Hyperlexia demonstrate significantly weak receptive and expressive vocabulary abilities implying that subjects with Hyperlexia are either not able to access a word lexicon or that their output lexicons are limited and concrete (Fontenelle and Alarcon 1982; Aaron 1989). It was therefore hypothesised that the children with Hyperlexia would display compromised single-word semantic skills.

The Peabody Picture Vocabulary Test - Revised (PPVT-R) was selected to explore the two groups' receptive vocabulary skills. This test uses a picture pointing task in which subjects point to the picture best representing each stimulus from a choice of four alternatives. The Expressive One Word Picture Vocabulary test was used to investigate the subjects' expressive vocabulary skills within a confrontation naming task. Table 4.2.3a shows the means, standard deviations and Z scores for the Hyperlexic and Dyslexic groups on these two measures. Both measures incorporate a standardisation mean of 100 with a standard deviation of 15.

Table 4.2.3a - Single Word Vocabulary:

| TEST   | MEAN    | SD       | Z SCORE |
|--------|---------|----------|---------|
| PPVT-R | H 107.3 | H 13.770 | 1.537   |
|        | D 113.1 | D 8.837  | 2.759** |
| EOWPVT | H 111.0 | H 13.520 | 2.317*  |
|        | D 114.6 | D 11.262 | 2.949** |

\* =  $p < 0.05$

\*\* =  $p < 0.01$

H = Hyperlexic group

D = Dyslexic group

One sample Z test scores thus revealed that the Hyperlexic group's scores were not significantly different to the norm for receptive vocabulary (PPVT-R), but were significantly stronger than the norm for expressive vocabulary (EOWPVT). The Hyperlexic group had a very high standard deviation on the PPVT-R (13.770) indicating that some subjects in the group performed at a very high level while others scored quite poorly.

In fact the Hyperlexic group's standard scores on the PPVT-R ranged from a low of 84 to a high of 128; unlike their performance on the SORT-R which revealed a much smaller standard deviation (6.022) with scores that ranged from a low of 106 to a high of 123. The current variation in receptive vocabulary suggests that some subjects with Hyperlexia are surprisingly poor at this skill given their reading ability. Nevertheless, the Hyperlexic group performed as a group above the population mean on the PPVT-R and significantly so on the EOWPVT.

The Dyslexic group's results on both the PPVT-R and EOWPVT were significantly strong as compared with the norm. Thus they are consistent with their nonverbal cognitive ability rather than their reading skill. Although the EOWPVT is a test of expressive vocabulary it does not measure word finding/ word retrieval skills, so that subjects may exhibit weaknesses with rapid automatic naming despite strong scores on the EOWPVT. Studies suggest a correlation between Developmental Dyslexia and naming difficulties (Denckla and Rudel 1976a/ 1976b; Leonard, Nippold, Kail and Hale 1983). The large standard deviation for the Dyslexic group suggested that some subjects displayed stronger vocabulary skills than others in the group.

t Test results confirm that the Hyperlexic group displayed no significant difference in their receptive and expressive single word vocabulary skills relative to the Dyslexic group.

(PPVT-R:  $t = 1.06(18), p < 0.05$ ), (EOWPVT:  $t = 102(18), p < 0.05$ ).

Results thus dispute the original hypothesis and contradict the proposal of significant breakdown in receptive and expressive single word semantic skills in the Hyperlexic group. In contrast, one is struck by their relatively strong performance, particularly on the EOWPVT, the measure of expressive vocabulary.

Single word level semantic skills have historically been an area of debate in the research on Hyperlexia. Authors including Aaron (1989) and Fontenelle and Alarcon (1982) report vocabulary skills to be poorly developed in subjects with Hyperlexia.

Aaron emphasised the contrast of abstract versus concrete vocabulary suggesting that subjects with Hyperlexia have greater difficulty with words in the former category.

Fontenelle and Alarcon also explored receptive vocabulary using the Peabody Picture Vocabulary Test. They obtained scores that varied dramatically from 57 -111.

Given the heterogeneity in cognitive levels of subjects diagnosed with Hyperlexia, one must be cautious when reviewing the implications of findings in the literature. Vocabulary skills may match verbal cognitive potential and, if subjects have varied widely in their cognitive skills, they may be expected to vary widely in measures of receptive vocabulary. In fact, the subjects investigated by Fontenelle and Alarcon displayed cognitive skills that varied from 57 -118.

The fact that their receptive vocabulary abilities varied similarly (57-111) is not a surprise and does not provide sufficient evidence to link receptive vocabulary weaknesses with the existence of Hyperlexia. Results from the current study support previous findings of Frith and Snowling (1983) and Goldberg and Rothermel (1984) who ruled out semantic difficulties at the single word level as the primary source for comprehension failure.

The present results indicate that both groups of subjects do have adequate semantic skills at the single word level apparently contradicting findings of Richman and Kitchell (1981) who suggested that subjects with Hyperlexia may store isolated bits of information without categorising and organising them in a meaningful fashion.

While the Hyperlexic group's semantic skills were unremarkable on a word level one can't help but wonder whether the breakdown only occurs when the stimulus involves the printed word i.e. when the individual must access the semantic system to comprehend a written word rather than a spoken word or picture stimulus. Future sections of this study will explore this possibility, but it is important to consider other word level linguistic skills first.

Previous research has suggested the presence of unusually good metaphonologic processing abilities in subjects with Hyperlexia. (Goldberg and Rothermel 1984). Superior metaphonologic facility has been linked with success in using the phonologic route to reading.

#### **b. Metaphonological abilities**

It was hypothesised that the Hyperlexic group would demonstrate significantly superior metaphonological skills.

Four subtests of the Woodcock Johnson Tests of Cognitive Ability (WJR-Cog) were administered. These measures included The Incomplete Words Subtest, a test of auditory closure; The Sound Blending Subtest; The Word Memory Subtest and The Numbers Reversed Subtest, a test of working memory. A mixed 2 Factor Analysis of Variance was conducted in order to explore the groups' functioning on these measures. The groups were identified as the between variable and the subtests as the within variable.

Results indicated a significant main effect for group (the Hyperlexic group performed significantly better than the Dyslexic group ( $F = 11.96 (18), p < 0.01$ ), but not for subtest, nor for the interaction between group and subtest.

Figure 4.2.3b illustrates the Hyperlexic and Dyslexic group scores on all subtests.

Figure 4.2.3b Graph of the mean performance of the Hyperlexic and Dyslexic groups on the Woodcock Johnson Metaphonologic Processing and Auditory Memory Subtests.

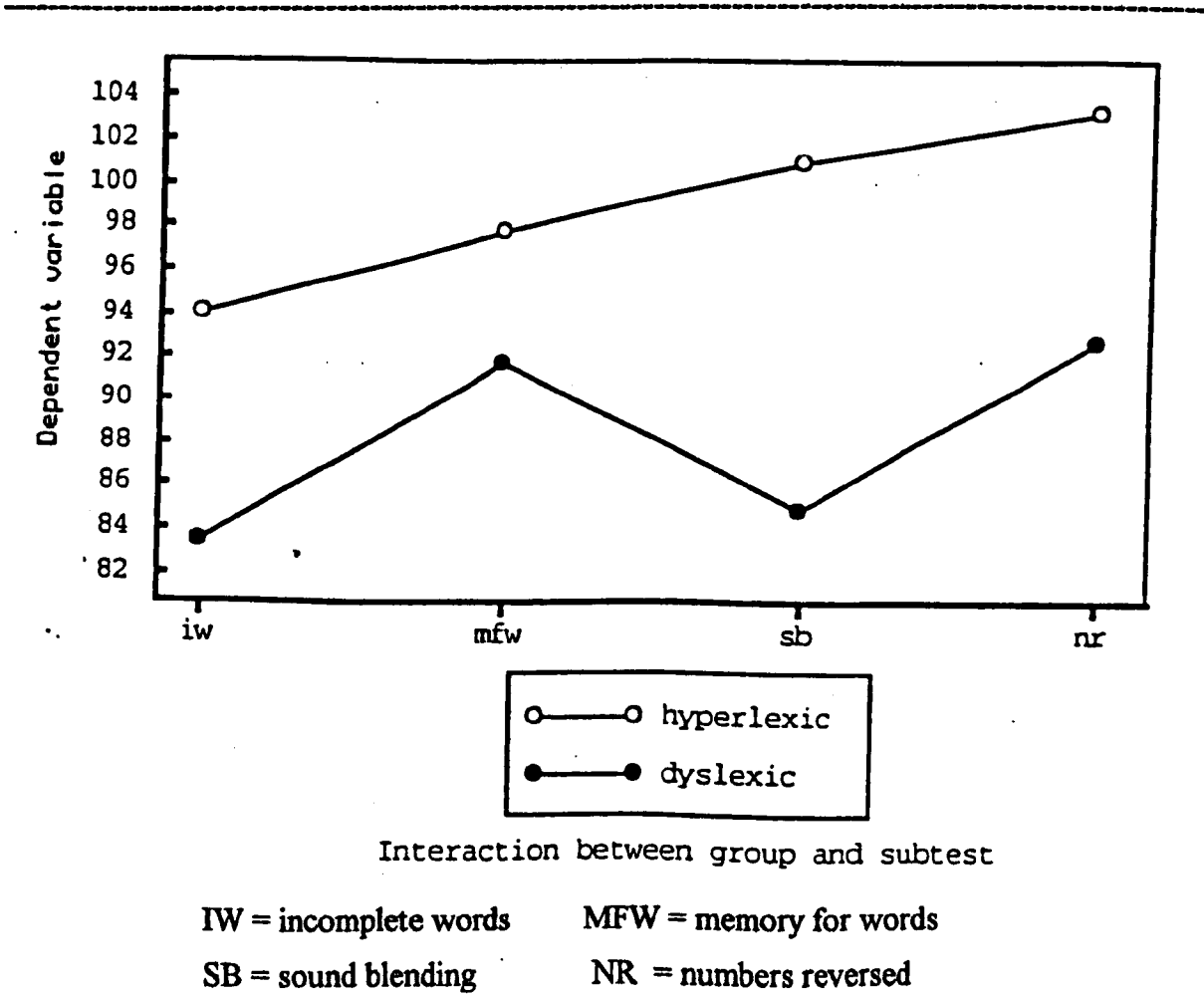


Table 4.2.3b presents the range of scores for both groups on all measures and highlights the extent of intersubject variability. The standardisation mean was 100 with a standard deviation of 15 for each subtest.

Table 4.2.3b-The Woodcock Johnson- Revised:Subtests

| SUBTEST                | GROUP | MEAN  | STD DEV | RANGE         |               |
|------------------------|-------|-------|---------|---------------|---------------|
|                        |       |       |         | MIN.<br>SCORE | MAX.<br>SCORE |
| INCOMPLETE<br>WORDS    | H     | 94    | 17.365  | 65            | 113           |
|                        | D     | 83.6  | 9.776   | 66            | 100           |
| SOUND<br>BLENDING      | H     | 100.8 | 24.298  | 68            | 144           |
|                        | D     | 84.8  | 11.380  | 66            | 100           |
| MEMORY<br>FOR<br>WORDS | H     | 97.6  | 13.167  | 79            | 121           |
|                        | D     | 91.6  | 10.627  | 76            | 111           |
| NUMBERS<br>REVERSED    | H     | 103.2 | 16.199  | 80            | 133           |
|                        | D     | 92.6  | 12.158  | 75            | 111           |

H = Hyperlexic group      D = Dyslexic group

Results indicated a high standard deviation for the Hyperlexic group especially on the Incomplete Words and Sound Blending subtests, revealing a high level of intersubject variability, with some subjects with Hyperlexia displaying distinctly weak skills on these tasks.

One sample Z test results comparing the Hyperlexic group and the Dyslexic group relative to the norm revealed that none of the Hyperlexic scores were significant relative to the norm, while the Dyslexic group's scores on the Incomplete Words (one sample Z test:  $Z = 3.518$ ,  $p < 0.01$ ) and Sound Blending Subtests (one sample Z test :  $Z = 3.202$ ,  $p < 0.01$ ) were significantly poorer than the norm. Results thus indicated that the Hyperlexic group did not show significantly strong metaphonologic or auditory memory skills as compared with the norm, and as a group, they performed significantly better on these tasks than the Dyslexic group, despite the high level of intersubject variability noted in their performance.

It is interesting to note that these results are contrary to that which would have been expected based upon prior studies (Goldberg and Rothermel 1984). Not only was the Hyperlexic group's performance unremarkable relative to the norm, but selected subjects demonstrated weaknesses on these measures. Prior studies have suggested the presence of phonological strengths impacting the exceptional decoding success of individuals with Hyperlexia. The Sound Blending and Incomplete Words Subtests purport to measure metaphonological skills and auditory memory, but it is possible that achievement on these measures may involve accessing of the semantic system.

For example, in order to demonstrate auditory closure skills on the Incomplete Words Subtest, subjects had to select sounds that would create a meaningful word response i.e. they were given a word that had a sound missing and had to identify the word it could be, bana-a = banana. There is the possibility that the need to access the semantic system interfered with selected subjects' performance and negatively impacted their scores. It is likely that individuals who demonstrate weaknesses in semantic access would have a delayed or aberrant response pattern on a task such as this, as one would need to activate plausible options (complete the given word with meaningful and relevant sounds) and if a subject demonstrated overt difficulty recognizing spoken real versus nonwords then deflated scores on Incomplete Words may reflect the contribution of breakdown in semantic access rather than a pure weakness in auditory closure exclusively.

It is proposed that breakdown in semantic access may have intruded on these tasks resulting in the inconsistent performance noted. This leads one to question the nature of other word level skills.

### c. Spelling

It was hypothesised that the Hyperlexic group would display significantly strong encoding of single words given their exceptional decoding strengths observed on the SORT-R. The Test of Written Spelling 3 (TWS-3) was used to explore the subjects' spelling of phonically predictable (regular) and unpredictable (irregular) words.

Subjects were required to spell words in two separate lists, one containing phonically predictable words and the other unpredictable words. The words were presented in spoken form, first in isolation, then given in a sentence/semantic context and finally repeated once more as the isolated word. Table 4.2.3c illustrates the means and standard deviations of the Hyperlexic and Dyslexic groups. The standardisation mean for each subtest was 100 with a standard deviation of 15.

Table 4.2.3c- The Test of Written Spelling-3

| SUBTEST                              | MEAN                  | STANDARD<br>DEVIATION | Z SCORE            |
|--------------------------------------|-----------------------|-----------------------|--------------------|
| PHONICALLY<br>PREDICTABLE<br>WORDS   | H 107.200<br>D 81.300 | H 9.647<br>D 6.201    | H 1.517<br>D 3.939 |
| PHONICALLY<br>UNPREDICTABLE<br>WORDS | H 106.300<br>D 71.000 | H 14.158<br>D 7.242   | H 1.327<br>D 6.109 |
| TOTAL SCORE                          | H 106.400<br>D 72.700 | H 10.690<br>D 8.341   | H 1.348<br>D 5.751 |

H = Hyperlexic group

D = Dyslexic group

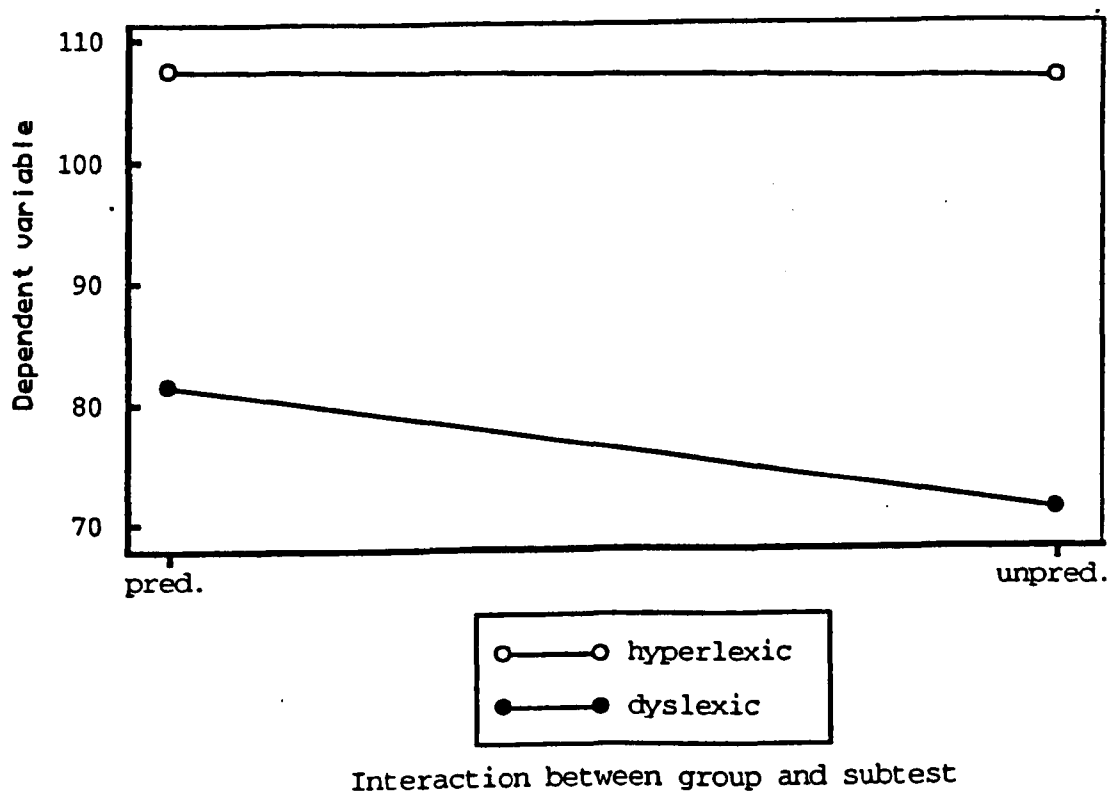
One sample Z scores indicate that the Hyperlexic scores were not significantly different to the norm, while the Dyslexic group's scores on all measures were significantly poorer (one sample Z score: Group with Hyperlexia  $Z=1.348$ , Group with Dyslexia  $Z = 5.751$ ,  $p<0.001$ ).

A mixed 2 factor analysis of variance with group as the between factor and subtest as the within factor reveals a significant main effect for group ( $F= 63.144 (18), p<0.000$ ), for subtest ( $F= 8.115 (18), p<0.01$ ) and in the interaction between group and subtest ( $F=5.754(18), p<0.05$ ).

Simple main effects showed that the groups differed on predictable words ( $F=35.0, p<0.000$ ) and unpredictable words ( $F=66.574, p<0.000$ ). Simple main effects also showed a difference between predictable and unpredictable words for the subjects with Dyslexia ( $F=13.768, p<0.0016$ ), but not for the subjects with Hyperlexia. The results suggest that the Hyperlexic group did not rely only on phonology for spelling and that they had good orthographic records of word spellings.

Figure 4.2.3c illustrates the mean performance of the two groups on the Test of Written Spelling-3.

Figure 4.2.3c Graph of the Mean Performance of the Hyperlexic and Dyslexic groups on the Test of Written Spelling -3



An analysis of the Hyperlexic group's single word linguistic skills thus points to strikingly good decoding, although other single word skills are mainly above the mean suggesting that they are not really discordant with reading.

In general, the results thus far have not pointed to any strong indication that the subjects with Hyperlexia are reading beyond their comprehension. Contextual reading measures may shed further light on this matter.

#### **4.2.4 Contextual Reading**

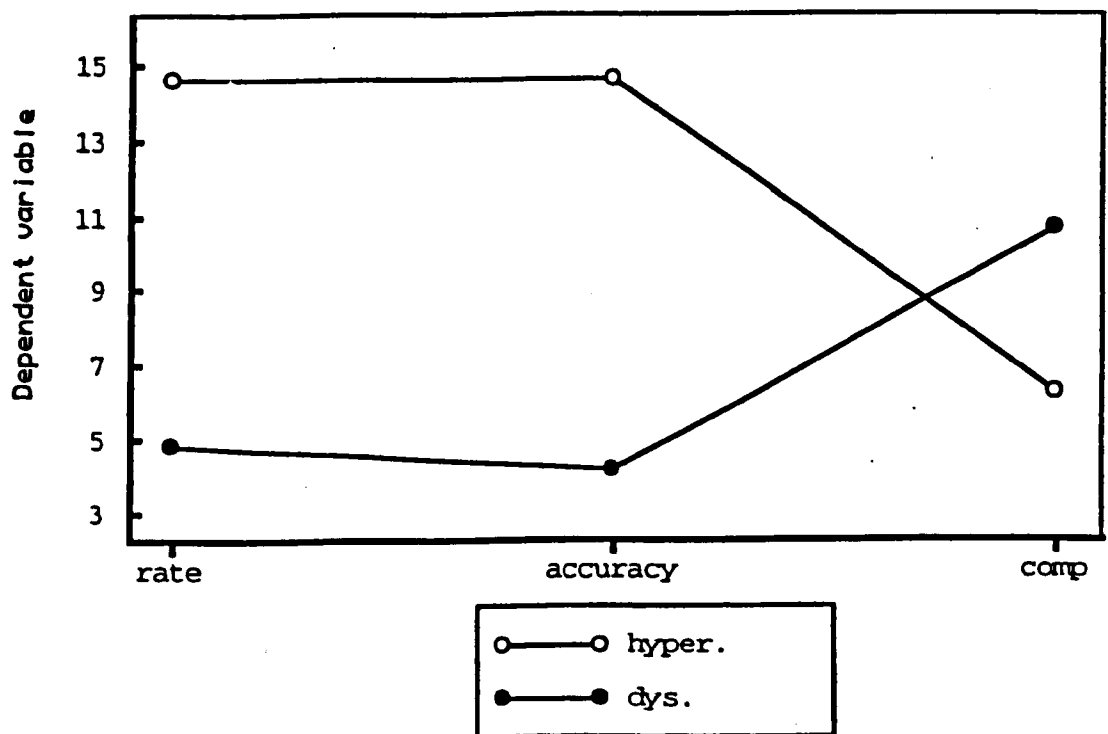
Contextual decoding and reading comprehension skills were measured using the Gray Oral Reading Test -3 (GORT-3). It was hypothesised that the Hyperlexic group would exhibit superior rate and accuracy and significantly weaker reading comprehension skills. The opposite profile involving intact comprehension in the context of significantly poor decoding skills is frequently attributed to those with Dyslexia. The GORT-3 required subjects to read passages out loud to the examiner. The subjects were timed to determine decoding rate and all errors were transcribed. Subjects were asked a series of comprehension questions following each story.

Figure 4.2.4 presents the mean scores for both the Hyperlexic and Dyslexic groups on the different submeasures.

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Figure 4.2.4 Graph of the Mean Performance of the Hyperlexic and Dyslexic groups on the Gray Oral Reading Test Revised (GORT-3)

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Interaction between groups and subtest

Table 4.2.4 shows the means, standard deviations, Z scores and significance levels for both the Hyperlexic and Dyslexic groups. The mean for the standardisation sample was 10 for each subtest and the standard deviation was 3.

Table 4.2.4- The Gray Oral Reading Test-3

| SUBMEASURE         | MEAN   | STANDARD DEVIATIONS | Z SCORE | LEVEL OF SIG. |
|--------------------|--------|---------------------|---------|---------------|
| RATE               | H 14.6 | 4.061               | +4.845  | **            |
|                    | D 4.8  | 2.394               | -5.477  | **            |
| ACCURACY           | H 14.6 | 2.591               | +4.845  | **            |
|                    | D 4.1  | 1.792               | -6.215  | **            |
| COMPREHEN-<br>SION | H 6.2  | 3.706               | -4.003  | **            |
|                    | D 10.6 | 1.713               | -0.632  | -             |

\*  $p < 0.05$

\*\*  $p < 0.00$

H = Hyperlexic Group    D = Dyslexic Group

One sample Z scores indicate that the Hyperlexic group's reading rate and accuracy were significantly stronger than the norm, while their reading comprehension skills were significantly poorer than the norm. In contrast, the Dyslexic group's reading rate and accuracy skills were significantly weaker than the norm and their reading comprehension abilities were not significant relative to the norm.

A mixed 2 factor Analysis of Variance was conducted with group as the between factor and subtest as the within factor. Results demonstrated that the Hyperlexic and Dyslexic groups differed overall on the GORT-3 ( $F=29.137(18), p<0.000$ ). A significant interaction between group and subtest ( $F=71.085(18), p<0.000$ ) was also found showing that the Hyperlexic group performed significantly better than the Dyslexic group on rate and accuracy but significantly more poorly on comprehension. Simple main effects show that differences between groups were significant for rate ( $F=59.028(18), p<0.000$ ); accuracy ( $F=67.761(18), p<0.000$ ) and comprehension ( $F=11.899(18), p<0.0011$ ). Results strongly confirm the original hypothesis indicating that the Hyperlexic group was uniform in both its exceptional decoding skill and its profound comprehension breakdown.

The results indicate abnormal functioning when comparing the Hyperlexic group with the norm, and the results are even more dramatic when comparing their functioning to that of the Dyslexic group. This finding supports information provided in the subjects' developmental histories and corroborates the core characteristics of Hyperlexia as discussed by Healy 1982; Richman and Kitchell 1981; Goldberg and Rothermel 1984; Snowling and Frith 1986 and Frith and Snowling 1983.

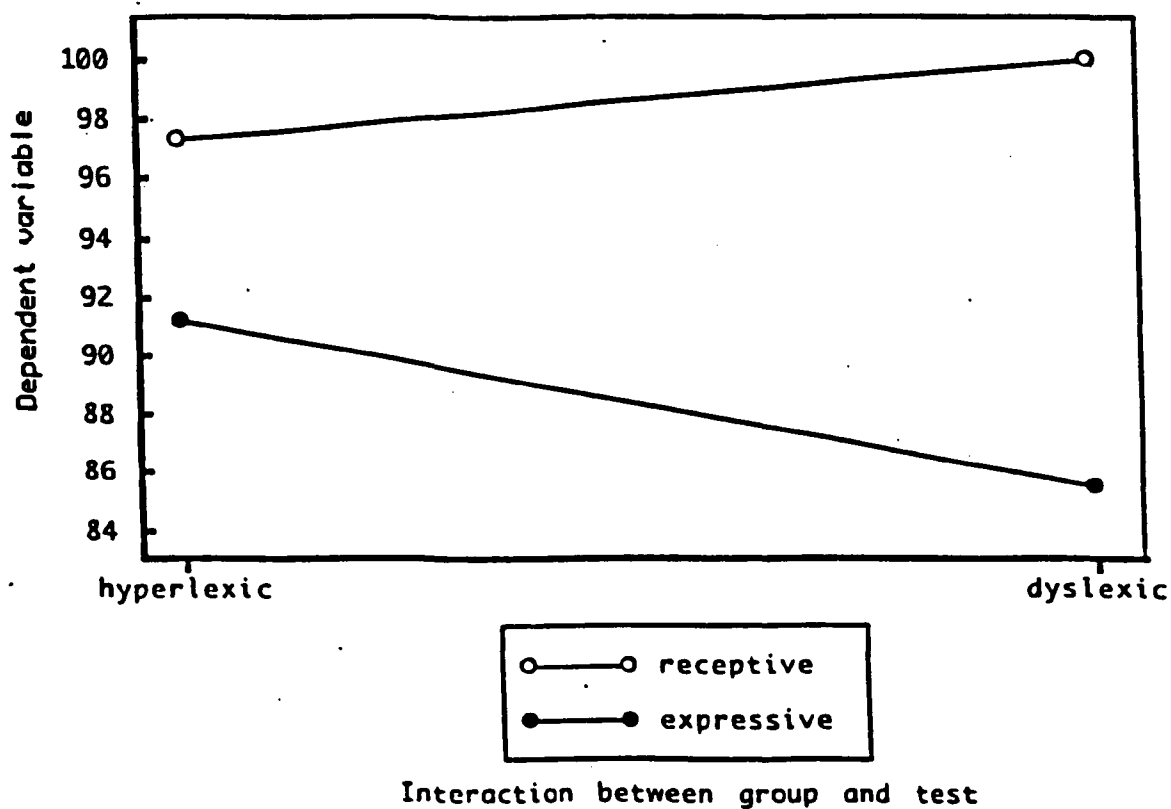
These findings are striking and point to a range of theoretical questions that warrant further investigation. The results clearly indicate unusually strong decoding of both single words and contextual level material in the Hyperlexic group. The results also reveal extremely weak text-level comprehension abilities. What accounts for these strengths and weaknesses? We have ruled out word level semantic skill deficits as the cause of comprehension breakdown but we have not explored contextual oral language skills. Perhaps breakdown at this level results in the reading comprehension difficulties evident on the GORT-3.

#### **4.2.5 Oral Language Skills**

A variety of measures were administered to explore the oral language skills of the subjects. It was hypothesised that the Hyperlexic group would demonstrate oral language weaknesses accounting for their reading comprehension breakdown. The Clinical Evaluation of Language Fundamentals Revised (CELF-R) was administered in order to explore both receptive and expressive oral language abilities.

Figure 4.2.5 reveals the Receptive and Expressive Language Scores from the CELF-R for both the Hyperlexic and Dyslexic groups. The standardisation mean was 100 for The Receptive and Expressive Language Scores with a standard deviation of 15.

Figure 4.2.5. Graph of the Expressive and Receptive Language Scores of the Hyperlexic and Dyslexic groups on the CELF-R.



A mixed two factor Analysis of Variance, with group as the between variable and receptive/expressive scores as the within variable illustrates a significant main effect for the type of measure ( $F = 47.268(18), p < 0.000$ ) indicating an advantage for receptive language. A significant interaction between type of CELF-R score and group ( $F = 7.490(18), p < 0.0022$ ) was also evident. This interaction reflects the fact that the Hyperlexic group performed better than the Dyslexic group on expressive skills and that the Dyslexic group's receptive skills were stronger than the Hyperlexic group's scores although simple main effects were not significant for either of these effects.

The CELF-R receptive language subtests comprised four different subtests. For three of these four subtests, the performance of the subjects with Hyperlexia was not significantly different to the norm or the Dyslexic group. Accordingly, this implies that the Hyperlexic group was able to successfully complete a range of tasks including following of oral directions in a picture pointing task. They were able to comprehend semantic relationships embedded in sentence level material and they could answer factual questions based on stories heard. The Hyperlexic group's scores were significantly weaker than the Dyslexic group ( $t = 2.26(18), p < 0.05$ ) on the Word Classes Subtest. This subtest presented subjects with four words and asked them to identify which two words went together best.

Although the Hyperlexic group's scores were significantly poorer than the Dyslexic group on this subtest, neither group was significantly different to the norm. The subtest mean for the standardisation sample was 10 and the standard deviation was 3. The one sample Z score for the Hyperlexic group was ( $Z = 0.843$ ) and for the Dyslexic group was ( $Z = 0.843$ ), suggesting that the subjects with Hyperlexia displayed age appropriate skills in this area.

Expressive Oral Language skills were investigated using three subtests of the CELF-R.

Table 4.2.5 indicates the means, standard deviation, Z scores and levels of significance for the expressive syntax measures. Each subtest had a standardisation mean of 10 and a standard deviation of 3.

**Table 4.2.5- The CELF-R Expressive Subtests**

| SUBTEST | MEAN  | SD    | Z SCORE | LEVEL OF SIG. |
|---------|-------|-------|---------|---------------|
| FS      | H 7.9 | 1.969 | -2.212  | *             |
|         | D 6.7 | 1.703 | -3.476  | *             |
| RS      | H 8.9 | 1.964 | -1.159  | -             |
|         | D 8.6 | 1.897 | -1.475  | -             |
| SA      | H 9.3 | 2.312 | -0.737  | -             |
|         | D 8.4 | 1.955 | -1.685  | -             |

FS = Formulated Sentences of the CELF-R

RS = Recalling Sentences of the CELF-R

SA = Sentence Assembly of the CELF-R

H = Hyperlexic group

D = Dyslexic group

\* =  $p < 0.05$

- = no significance

The Hyperlexic and Dyslexic groups obtained significantly poorer results than the norm on the Formulated Sentences Subtest ( $p < 0.05$  for both groups). A mixed two factor Analysis of Variance with group as the between factor and subtest as the within factor indicated no significant difference when the Hyperlexic and Dyslexic groups were compared with each other on each of the subtests described above.

Results thus suggested compromised oral formulation skills in both groups. A variety of reasons can be proposed to account for this weakness in the Hyperlexic group. The Formulated Sentences Subtest of the CELF-R provides subjects with a picture stimulus and a spoken word for each item. The subjects were required to formulate a sentence using the given words.

It is possible that the subjects with Hyperlexia exhibit underlying receptive syntactic weaknesses influencing their expressive syntactic output. In order to check receptive syntactic skills, Bishop's (1982) Test of Reception of Grammar (TROG) was administered. Test results indicate no significant difference between those with Hyperlexia and those with Dyslexia in their functioning on this test ( $t = 0.12$  (18)), with no significant receptive syntactic weaknesses exhibited by either group. Receptive syntactic weaknesses do not therefore account for the oral formulation breakdown.

Another possibility is that the scores of the subjects with Hyperlexia could be compromised by potential difficulties ensuring that the sentences they produced related to the given picture stimuli. This would indicate a pragmatic language difficulty suggesting that weaknesses identifying relevant features of the picture and relating them to the given word may contribute to poorly formulated responses.

Case history information certainly points to pragmatic language difficulties evident in the group with Hyperlexia and may account for or contribute towards weakness in on-demand sentence formulation tasks.

#### **4.2.6 Pragmatic Skills**

Informal pragmatic language checklists were provided to the families of the children with Hyperlexia to gain further insight into the nature of the pragmatic language symptoms documented in the children's developmental histories. Data from this checklist confirmed ongoing family concern regarding social pragmatic issues including weak discourse skills, poor timing of remarks and difficulties with turntaking amongst all the subjects with Hyperlexia.

It was thus hypothesised that the subjects with Hyperlexia would display pragmatic language weaknesses on the Test of Pragmatic Language (TOPL), one of the few standardised measures available that investigate this area.

Table 4.2.6 illustrates the mean and standard deviation for each group on the TOPL. The standardisation mean was 100 and the standard deviation was 15.

Table 4.2.6 - The Test of Pragmatic Language:

| TEST | MEAN    | STD. DEVIATION |
|------|---------|----------------|
| TOPL | H 91.52 | H 10.723       |
|      | D 97.10 | D 10.005       |

H= Hyperlexic group

D=Dyslexic group

Independent t test results indicated that the subjects with Hyperlexia did not differ significantly from the subjects with Dyslexia on this measure ( $t=1.203(18), p<0.245$ ). The Hyperlexic group did however differ significantly from the norm as demonstrated by one sample Z scores ( $Z=-1.786, p<0.05$ ) verifying pragmatic language weaknesses in the test group.

Once again one is struck by the vast amount of intersubject variability within the Hyperlexic group. Scores ranged from a low of 70 to a high of 107, indicating a scatter of skills in this area, with one subject scoring particularly poorly on this test. This specific subject's scores on other formal measures were not as discrepant from the rest of the Hyperlexic group indicating that he did not constantly score differently to the rest of his group.

There are a paucity of studies that have specifically addressed pragmatic language issues and Hyperlexia. The current findings support a prior study by Healy, Aram, Horwitz and Kessler (1982) who documented disordered pragmatics in their subjects with Hyperlexia, both in terms of comprehension and production. They described the difficulties their subjects had relating to peers and how they were reported to be inflexible and intent on activities of their own choice. They documented problems with social use of language both with peers and adults, although they did not elaborate on specific social language breakdown.

Formal measures such as the TOPL are limited in their effectiveness in identifying the range of pragmatic language weaknesses evident in the Hyperlexic group. Chapter One included informal documentation of a number of pragmatic language issues evident in the subject group, not necessarily manifest in formal testing, suggesting the need for more in-depth investigation of this area.

#### **4.3 Conclusion**

This chapter has begun to illustrate the complex nature of the breakdown associated with the subjects with Hyperlexia. The chapter commenced with an exploration of language-based skills using standardised tests. As such, the children with Hyperlexia were compared with normal controls on these measures.

In addition, a comparison group of children with Dyslexia was used in order to explore the two seemingly mirror image reading profiles.

Results suggested that the children with Hyperlexia displayed no significant difference to the normal controls on many measures including nonverbal intelligence. Superior scores were obtained by the children with Hyperlexia in their reading of single words, and in their contextual reading rate and accuracy. Single-word semantic skills were explored and it was determined that the vocabulary skills of the children with Hyperlexia fell above the population mean and deficits at this level could therefore not account for Hyperlexic symptomatology.

Other single word skills including metaphonological and spelling abilities were also investigated. It was determined that the Hyperlexic group's metaphonological skills were unremarkable and in some instances significantly poorer than the mean suggesting that their decoding strengths could not be accounted for by exceptional metaphonological abilities. The children with Hyperlexia demonstrated age appropriate spelling skills and did not exhibit exceptional skills in this area either. The chapter went on to investigate contextual reading to identify whether subjects with Hyperlexia were in fact decoding at a level beyond their comprehension.

This hypothesis was clearly confirmed with significant weaknesses were noted in the Hyperlexic group's reading comprehension skills, despite significant strengths in their decoding rate and accuracy. In order to better understand this overt discrepancy, contextual oral language skills were investigated. It was determined that the children with Hyperlexia exhibited compromised oral formulation skills despite adequate receptive syntax skills, while significantly weak pragmatic language abilities were confirmed.

The children with Hyperlexia were also compared to the children with Dyslexia. A number of overt differences between the two groups confirmed that the two disorders may represent mirror images of one another specifically as they relate to the decoding process. As such, the children with Hyperlexia exhibited significantly strong single-word decoding as compared with the children with Dyslexia whose skills in this area were significantly weak.

The children with Hyperlexia demonstrated significantly strong contextual reading rate and accuracy in the face of significantly weak reading comprehension, while the opposite profile was displayed by the children with Dyslexia. The children with Dyslexia also presented with significantly weak spelling skills as compared with the children with Hyperlexia. Despite these clear and overt differences, a number of similarities were also evident between the two comparison groups. These included the lack of discrepancy between their single word semantic skills in particular.

It was determined that the Hyperlexic group performed better than the Dyslexic group on expressive contextual oral language measures while the Dyslexic group's performance was stronger than the Hyperlexic group on receptive tasks, although simple main effects were not significant for either effect. Compromised oral formulation skills were identified in both groups and were not reflective of receptive syntactic weaknesses.

Two sets of questions have therefore arisen from the set of standardised measures administered.

These questions centre around the two broad themes of decoding success and comprehension failure. This chapter has verified the presence of unusual decoding success in the Hyperlexic group. However our understanding of the nature of their decoding strength is still limited.

We do not know if re-administration of reading tests would indicate a consistent reading pattern amongst subjects. Although we have evidence that the subjects with Hyperlexia can read regular and irregular words, we do not know whether they prefer one route to reading or another.

To discover this we would need to investigate whether their reading is affected by variables such as word frequency, regularity, imageability and familiarity. In addition, we do not know how subjects with Hyperlexia acquire new printed words and whether their learning of novel words is different from normal peers.

There are a number of questions that emerge related to their comprehension failure as well. We do not have in-depth understanding of the comprehension deficit. Although the subjects with Hyperlexia demonstrate adequate word level semantic skills for oral tasks we do not know if they comprehend the words they read, as we do not have a direct comparison of their reading and comprehension of single words. We also do not know whether there would be a significant difference in their auditory versus reading comprehension of contextual material.

We do not truly understand the nature of their pragmatic language difficulty and the impact of weaknesses in this area on comprehension failure. These issues are the impetus for further investigations.

## **Chapter 5 - The GORT-3 Revisited and Extended**

### **5.1 Rationale**

The Hyperlexic group's unusual decoding success and equally perplexing reading comprehension failure on the GORT-3 was highlighted in Chapter 4. Reasons accounting for both the decoding success and comprehension failure could not be identified despite the exploration of sound, word, sentence and paragraph level abilities on a variety of other tests. While isolated linguistic weaknesses were apparent, these did not seem adequate to explain the unusual profile seen in reading. This chapter will address the comprehension failure in greater depth. It will investigate comprehension of the spoken form relative to the written form. If the Hyperlexic group's auditory comprehension of like-material is significantly stronger than their reading comprehension, it would suggest that subjects with Hyperlexia are better able to access the semantic system if stimuli do not involve the printed word. This would imply breakdown in the connection between the visual input lexicon and the semantic system, and indicates that reading aloud was achieved largely by use of the Visual Input Lexicon to Phonemic Output Lexicon, the Direct Route to reading.

As a period of a year had passed since the administration of the original GORT-3 tests, the present assessment both readministered the traditional written version of the test thus allowing performance to be assessed over time, and used an auditory version of the test to compare the two modalities.

Before investigating auditory comprehension relative to visual comprehension, the consistency of reading comprehension was checked..

## 5.2 Method

No subject received the auditory and written version of the task in one setting. The written version required subjects to read the given stories out loud to the researcher. Each passage was scored in terms of the subjects' reading rate and accuracy. After each passage was read aloud, subjects were asked comprehension questions about that passage. As the GORT-3 has two forms, A and B, subjects were presented with one form as the reading task and the alternate form for auditory comprehension, so that form and order of tasks were counterbalanced across subjects.

The stories and questions for the auditory task were read onto tape in a sound-proof booth by an adult American Male who was a Speech Therapy Aide in the Speech Therapy Department at the Lab School of Washington, U.S.A. The auditory form was administered using a tape player in a quiet environment. Subjects were told that they would listen to stories on tape and after each story was presented they would be required to answer some comprehension questions. As with the written version, subjects were informed that they would be given a brief introduction to each story prior to beginning. The basals and ceilings used for the auditory version of the GORT-3 were the same as that for the traditional format.

## 5.3 Results

### 5.3.1 The GORT-3 Now and Then

A comparison of the subjects' performance on the two written versions administered a year apart occurs first to assess potential changes in performance over time. It was predicted that the children with Hyperlexia would continue to display a significant mismatch between their superior reading rate and accuracy and their significantly weak reading comprehension skill.

Table 5.3.1 presents the scores for both groups on the initial and second assessment of the GORT-3 (using the traditional written format).

Table 5.3.1 : The GORT-3

| SUBTEST       | MEAN FOR THE<br>HYPERLEXIC GROUP |       | MEAN FOR THE<br>DYSLEXIC GROUP |       |
|---------------|----------------------------------|-------|--------------------------------|-------|
|               | MEAN                             | S.D.  | MEAN                           | S.D.  |
| RATE          | A. 14.600                        | 4.061 | A. 4.800                       | 2.395 |
|               | B. 15.400                        | 2.989 | B. 4.300                       | 2.406 |
| ACCURACY      | A. 14.600                        | 2.591 | A. 4.100                       | 1.792 |
|               | B. 13.600                        | 2.757 | B. 3.400                       | 2.319 |
| COMPREHENSION | A. 6.200                         | 3.706 | A. 10.600                      | 1.713 |
|               | B. 4.900                         | 3.725 | B. 9.600                       | 2.757 |

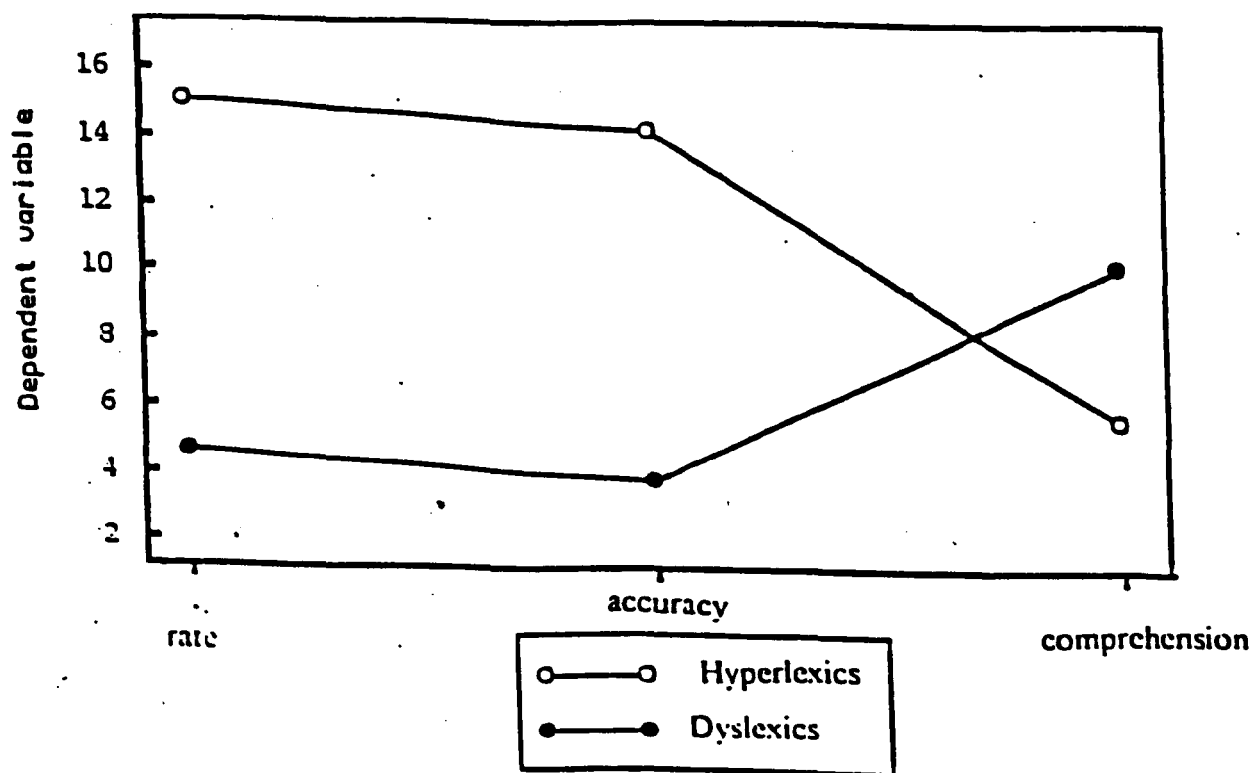
A = initial administration    B = second administration

The scores were subjected to a 3 factor analysis of variance with group as the between factor, and time and subtest as the within variables. No significant main effect was noted for time ( $F(1,18) = 1.768, p < 0.2003$ ), nor were there any significant interactions involving time indicating that neither overall performance nor the profile of that performance had changed.

The interaction previously found between group and subtest continued to be significant ( $F(1,18) = 82.102, p < 0.001$ ), and a difference was again found between the Hyperlexic and Dyslexic groups ( $F(1,18) = 43.907, p < 0.000$ ). Simple main effects carried out on the interaction show that the two groups differed significantly on each of the 3 subtests.

(Rate:  $F(1,18) = 87.136, p < 0.000$ ), (Accuracy:  $F(1,18) = 85.476, p < 0.000$ ), as well as (Comprehension:  $F(1,18) = 16.519, p < 0.000$ ). Figure 5.3.1 illustrates the interaction between group and subtest on the GORT-3.

Figure 5.3.1 The interaction between group and subtest on the GORT-3



Interaction between group and subtest

Although the mean comprehension scores for the two groups did not change over time, individual subjects varied in scores, particularly in the Hyperlexic group, in which subjects were more inconsistent in terms of the direction in which their scores changed. The mean difference was 2.9 for the Hyperlexic group and 1.4 for the Dyslexic group. This may reflect the Hyperlexic group's poor performance generally and their tendency to guess responses. Nonetheless, since the two assessments do not change overall it is reasonable to use the mean of the two assessments as a more reliable indicator of their true performance than either of the written assessments alone.

### **5.3.2 Auditory versus Written Comprehension**

It was hypothesised that the children with Hyperlexia would be better able to access semantics auditorally, suggesting breakdown in the connection between the visual input lexicon and the semantic system.

Table 5.3.2 illustrates the means and standard deviations for the Dyslexic and Hyperlexic groups on the auditory versus the written comprehension tasks. The following analysis compares the subjects' performance on the comprehension questions only.

**Table 5.3.2- Auditory versus Written Comprehension**

|                       | WRITTEN<br>COMPREHENSION | AUDITORY<br>COMPREHENSION |
|-----------------------|--------------------------|---------------------------|
| MEAN                  | H 4.9<br>D 9.6           | H 7.7<br>D 9.9            |
| STANDARD<br>DEVIATION | H 3.725<br>D 2.757       | H 1.252<br>D 2.283        |

H = subjects with Hyperlexia

D = subjects with Dyslexia

A two Factor mixed analysis of variance with group as the between factor and modality of comprehension scores as the within factor, indicated that the two groups performed significantly differently from each other ( $F(1,18)=13.871$ ,  $p<0.01$ ). Modality (i.e. auditory or written presentation of material) approached significance ( $F(1,18)=3.542$ ,  $p<0.07$ ). The interaction between group and modality was however significant ( $F(1,18)=5.144$ ,  $p<0.05$ ). Simple main effects revealed that the two groups performed significantly differently from each other for reading comprehension ( $F(1,36)=19.000$ ,  $p<0.0001$ ) and for auditory comprehension ( $F(1,36)=4.442$ ,  $p<0.05$ ) with the Dyslexic group's scores being significantly better than the Hyperlexic group's in both areas.

Simple main effects also demonstrated that modality was significant for the Hyperlexic group ( $F(1,18)=8.611$ ,  $p<0.01$ ) but not for the Dyslexic group ( $F<1$ ).

The latter result shows that the Hyperlexic group performed significantly better for auditory comprehension than for reading (written) comprehension, while the same was not true for the Dyslexic group. Nonetheless, although auditory presentation of information appeared beneficial for the Hyperlexic group, their auditory comprehension remained significantly worse than that of the Dyslexic group.

The above results suggest that auditory input allows for easier accessing of the semantic system than written presentation of material, pointing to the possibility that in Hyperlexia the comprehension deficit is partly modality specific. This finding is in contrast to Huttenlocher and Huttenlocher (1973) who concluded that their subjects could process only a limited amount of information at a time regardless of whether the material was presented via the auditory or visual route, a result pointing again to the heterogeneity attributed to this population.

What accounts for this discrepancy?

One possibility is that the inferior reading comprehension of the Hyperlexic subjects relates to their rapid reading rate which may be preventing them from comprehending the read material. This seems plausible because rate is slowed in auditory presentation thus providing subjects with a greater opportunity to enhance their understanding.

If, however, rate was the only factor involved, one would have expected the subjects with Hyperlexia to perform normally on the Auditory Comprehension task, yet their performance was still weak in this domain albeit significantly better than their reading comprehension. This finding does not rule out the possibility that rate may still impact comprehension. In order to investigate this, the relationship between rate (written task) and change in comprehension (written to auditory) was explored.

A positive correlation would indicate that high rates in reading are related to a substantial change in comprehension suggesting a role for rate in further comparing comprehension. Although the correlation was quite high, ( $r = 0.54$ ), given the small number of subjects, it failed to reach significance ( $p=0.106$ ).

Another possible reason why the Hyperlexic group could read rapidly and accurately, but fail to comprehend the information, may be that they knew their comprehension was poor and gave little attention to comprehending the material, preferring to focus on the fluency and accuracy of presentation which they find easy and enjoyable. In addition, the subjects read the text extremely rapidly and without pause, not making use of intonation cues to aid comprehension i.e. they read in a monotone without proper consideration of punctuation.

The results suggest that all three factors are plausible explanations for the mismatch and point to the need to explore the comprehension deficit in greater detail.

The results of the Dyslexic group are also striking, revealing that their reading comprehension skills were as good as their auditory comprehension abilities despite significant decoding problems.

#### **5.4 Inferential Comprehension**

The study thus far clearly demonstrates that the Hyperlexic group displayed significant comprehension breakdown on the GORT-3 in its traditional format. Breakdown in comprehension with auditory presentation of the GORT-3, albeit less severe, was nonetheless also apparent. The Hyperlexic group's success and seemingly unremarkable performance on other measures of oral comprehension presented in Chapter 4 raises the question of what differentiates these measures. Several of these formal tasks focus on the recall of overtly provided factual information.

It is possible to broadly differentiate those questions on the GORT-3 that require factual recall of information contained within the story from those that require the subjects to make inferences that go beyond the basic content of the story. In counting the number of questions that could be associated with each category it was determined that the GORT-3 comprises a heavy inferential component.

The test certainly contains questions that draw on specific excerpts of text. This is exemplified in the question, "*What is the man holding,*" which requires the subject to recall the precise object that the man in the story was holding.

Nonetheless, a greater number of questions require connections between bits of text. For example, the question "*Why do you think jazz has not become part of the mainstream of American Music?*" requires the subjects to synthesise ideas from throughout the passage, whilst simultaneously considering the author's perspective which may be different to their own. In fact, many questions rely on the subjects' ability to understand intent, main ideas, attributes, feelings and thoughts of characters, questions that extend far beyond the simple recall of data from the text.

On several occasions subjects are asked to determine which sentence (out of a group of 3 or 4) does not belong in the story. Here, subjects are required to make inferences demanding exclusionary skills, whilst on other occasions they are required to infer characters' feelings and determine the sort of person a character is from another character's perspective (e.g *Harriet regards Mr Weston as a man who.....*). In light of these different question types it is plausible that weak scores do not reflect poor comprehension of the text itself, but rather the subjects' difficulty interpreting the examiner's intent and the purpose of the questions.

In order to investigate comprehension of factual material, an additional formal measure of reading comprehension was administered. The Paragraph Reading Subtest of the Test of Reading Comprehension (TORC) was selected to explore the Hyperlexic and Dyslexic group's ability to read given paragraphs silently and answer factually oriented questions that followed each paragraph. It was predicted that the children with Hyperlexia would exhibit stronger reading comprehension skill for factual information.

Each subject was given a test booklet and told to read each paragraph quietly to themselves and answer the questions that followed. Basals and ceilings were obtained as per test requirements.

Table 5.4 illustrates the means and standard deviation for the Hyperlexic and Dyslexic groups on the TORC. The mean for the normative control group was 10, with a standard deviation of 3.

**Table 5.4- The Test of Reading Comprehension (Paragraph Reading Subtest)**

|                       | MEAN   | STANDARD<br>DEVIATION |
|-----------------------|--------|-----------------------|
| Group with Hyperlexia | 10.900 | 2.8460                |
| Group with Dyslexia   | 9.400  | 2.6750                |

Both t Test results ( $t=1.21$ ) used to compare the Hyperlexic and Dyslexic groups and z scores used to compare each group with the norm were not significant.

Overall results thus indicated that the Hyperlexic group demonstrated age appropriate comprehension of written factual information. This test shares with the GORT-3 the use of paragraph level material to assess comprehension, however the information required is more factual in nature.

The success of the Hyperlexic group on this test rules out the possibility that they fail merely because of the quantity of information provided and makes it more likely that it is the nature of the information required that results in their failure. The comprehension breakdown on the GORT-3 may therefore relate specifically to understanding of inferential material and the type of questions asked.

Preliminary observations of the Hyperlexic group suggest that even when they demonstrate basic understanding of the factual material contained in a passage they still may have difficulty applying the knowledge effectively.

For example, one subject with Hyperlexia read a passage contrasting life in the countryside with life in an urban city. He was asked to recognise the advantages of living in the countryside for a person who likes the country life. He was then asked to identify the advantages of city life for the "city kid". Thereafter, the teacher asked him to discuss the perspective of the city kid who had to live in the countryside.

This subject was unable to answer this question correctly despite his correct responses to the prior two questions.

Questions that ask the subjects to integrate the information and adjust their responses according to the situation and context, explore a different form of comprehension than those investigating the recall of detailed facts overtly provided in the text.

Further exploration of comprehension of the intents of others, and the influence of pragmatic language abilities on meaning beyond the sentence level, may shed light on the quality of reading comprehension breakdown observed.

Chapter 7 will consider different forms of comprehension in greater detail and will discuss the impact of pragmatics on comprehension.

### **5.5 The GORT-3 - a Conclusion**

Re-administration of the GORT-3 allows us to draw conclusions about a number of factors.

We now can confirm the relative stability of superior reading rate and accuracy over time.

This implies that the initial seemingly bizarre findings reflect a consistent reading pattern.

Reasons accounting for this reading pattern remain unanswered. We still do not know whether subjects with Hyperlexia favour one route over another. We also do not know how they learn novel written words.

We have established that the Hyperlexic group continues to display significantly poor reading comprehension despite some fluctuation in individual scores. In addition, we found that this group performed significantly better when answering comprehension questions (matched for difficulty) presented auditorily. Nonetheless, their scores remained significantly poorer than the Dyslexic group. In comparing potential reasons for their comprehension deficit we can conclude that the deficit is partly modality specific and that the deficit appears more linked to comprehension of inferential material rather than factual information. In fact, the Hyperlexic group performed in the average range when answering reading comprehension questions targeting more overt factual details provided in the passages. There is also a hint that rate of reading may interact with comprehension.

Although the relationship between rate and comprehension was not significant, it approached significance suggesting that reducing the reading rate of subjects with Hyperlexia could improve comprehension, a significant finding with possible implications for intervention.

This chapter has highlighted once again, the two central themes of decoding success and comprehension failure. It has further been shown that comprehension failure is not confined to written language, and affects some types of meaning more than others. Subsequent chapters pursue each of these issues.

## **Chapter 6 - A further look at Decoding Success**

### **6.1 Reading Routes and Hyperlexia**

The study thus far has shown superior decoding ability in the Hyperlexic group both on a single word and a text level. Given their extremely proficient reading ability we can predict that they may employ each of the different routes to reading aloud. Nonetheless, we do not know how the individual with Hyperlexia embarks upon the reading process or the nature of their decoding strength. We do not know whether they display an unusual dependence on any one reading route and we do not know which route, if any, they prefer. Awareness of these issues will provide us with a source of insight into how they are reading and into the nature of their reading strength. The reader is referred to Chapter 3 for an in-depth discussion of the various reading routes.

The different reading routes will be investigated through use of a select number of subtests from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) 1992. Subtests exploring effects of imageability, frequency, regularity and familiarity will be targeted using these measures. Although PALPA is designed for adults (albeit for those with Acquired Aphasia) and it assumes that subjects have a fully developed reading vocabulary, a number of reasons justified its choice. Firstly, PALPA allows one to assess routes to reading by having tests of matched stimuli specifically for this purpose.

Secondly, it is interesting to examine the functioning of subjects with Hyperlexia on a measure designed for adults, given their unique and unusual decoding talents. PALPA provides norms for non-aphasic adults which are extremely useful in directly comparing the subjects with Hyperlexia and adult readers as if the children with Hyperlexia do well on these tests they are performing as adult experienced readers.

Additionally, a synonym selection task will be devised in order to examine whether the subjects with Hyperlexia read words they do not comprehend. Finally, novel word learning tasks will be introduced in order to further investigate reading routes and Hyperlexia.

## 6.2 How do subjects with Hyperlexia compare with adult readers?

The Imageability and Frequency Reading Subtest of PALPA was used to compare the Hyperlexic group with normal controls. This subtest of the PALPA investigates effects of imageability and frequency (as well as their interaction) on reading aloud. This test is designed for adults who are aphasic. As normal adults perform at ceiling on this measure its difficulty level is uncertain. However, it does not exclude items which are likely to be unfamiliar to children. Nevertheless, it was expected that the Hyperlexic group's high level of skill at decoding words would allow them to perform well and that the errors they would make would pertain either to low frequency words or those words they had not encountered previously. The subtest itself incorporates four different word sets.

Half of all the words are high in imageability and half are low in imageability.

The same is true for frequency. There are therefore four word tests (high imageability-high frequency, high imageability-low frequency, low imageability -high frequency, low imageability-low frequency). Number of letters, syllables and morphemes as well as grammatical class are controlled.

Subjects were given two pages of randomly presented words to read aloud. There were 4 words per line and 10 lines per page. Results were scored as correct or incorrect. Appendix B includes the stimuli for this subtest. Table 6.2 shows the means and standard deviations for the reading of words of high imageability/high frequency (HI/HF), low imageability/high frequency (LI/HF), high imageability/ low frequency (HI/LF) and low imageability/low frequency (LI/LF) for the Hyperlexic and the normal adult control groups.

Table 6.2-Imageability and Frequency

|                       | HI/HF               | HI/LF               | LI/HF               | LI/LF               |
|-----------------------|---------------------|---------------------|---------------------|---------------------|
| MEAN                  | H 19.90<br>NC 19.94 | H 19.70<br>NC 19.94 | H 19.00<br>NC 20.00 | H 17.90<br>NC 19.52 |
| STANDARD<br>DEVIATION | H 0.32<br>NC 0.25   | H 0.67<br>NC 0.07   | H 0.94<br>NC 0      | H 1.20<br>NC 0.68   |

H = Hyperlexic group

NC = normal controls

The subjects with Hyperlexia perform well on this test. Their performance is broadly comparable with normal adult controls, although they score lower on words of low imageability and low frequency.

A 2 factor within subject Analysis of Variance was used to compare performance on the different word sets. This found a main effect of Imagery ( $F(1,9) = 27.22, p < 0.01$ ) and a main effect of frequency ( $F(1,9) = 12.57, p < 0.05$ ). The interaction of these variables just failed to reach significance ( $p < .07$ ). These results show that the reading of the subjects with Hyperlexia is affected by word imagery and frequency.

### 6.3 Is there a regularity effect in Hyperlexic reading?

Reliance on the phonological route to reading would produce individuals who are more successful at decoding regular as compared with exception words, as pronunciation of regular words may be derived from the application of grapheme-phoneme correspondences. Given the Hyperlexic group's strength in oral reading it would be surprising if they were relying on one route to the exclusion of another. Rather, as with adult readers, one would expect these subjects to use all routes effectively and to rely on the phonological route when approaching unknown or extremely low frequency words. In this way a regularity effect may be expected even if subjects with Hyperlexia can read visually and therefore are able to successfully decode some irregular words.

The Oral Reading-Regularity Subtest of PALPA was selected in order to explore regularity effects on the decoding process, comparing the subjects with Hyperlexia and the normal adult controls. This task investigates reading skills that could be affected by spelling-sound regularity.

Both regular and exception words are matched for word frequency, imageability, grammatical class and number of letters, syllables and morphemes. The reader is referred to Appendix B for a full list of test stimuli.

Subjects were shown a page of 40 words, four words per line with ten lines on the page, and asked to read the words out loud to the researcher. Words were scored as correct or incorrect.

Table 6.3 shows the means and standard deviations for the Hyperlexic and normal control groups in their reading of regular and exception words.

Table 6.3 -Regular and Exception Words

|                       | REGULAR WORDS        | EXCEPTION WORDS      |
|-----------------------|----------------------|----------------------|
| MEAN                  | H 29.200<br>NC 29.96 | H 24.900<br>NC 29.85 |
| STANDARD<br>DEVIATION | H 0.2<br>NC 0.2      | H 0.809<br>NC 0.37   |

H = Hyperlexic group

NC = normal control

Related t Test results confirmed that the Hyperlexic group displayed a regularity effect ( $t = 5.26, p < 0.001$ ).

An analysis of errors on this task revealed that the errors made by the subjects with Hyperlexia occurred on words of low frequency suggesting that the Hyperlexic group could decode the high frequency words visually and phonologically if regular, but for words they did not know (low frequency words) they resorted to phonological strategies thereby resulting in a regularity effect. Of the 59 errors made by the Hyperlexic group none involved high frequency words. Eight errors related to decoding of low frequency regular words (words that occur with a lower frequency than 15). Fifty-one errors related to irregular words and of those fifty-one errors, forty-one of them were made in words with a frequency lower than 15 and the remaining 10 with a frequency lower than 38. The results thus strongly support the regularity effect present only as it relates to the decoding of low frequency/unfamiliar words.

#### 6.4 Confirming the intactness of the phonological route

Given the responses of the children with Hyperlexia to the previous measure, it was hypothesised that they would display intact use of the phonological route in additional measures including those investigating nonword reading.

As decoding of nonwords requires exclusive use of grapheme-phoneme conversion, The Oral Reading: Nonwords Subtest of the PALPA was selected. This task incorporated 24 monosyllabic nonwords that varied in letter length from 3-6 letters. Appendix B includes all the stimuli involved in this measure. Subjects were told that they had to read some made-up nonsense words out loud to the examiner. All responses were scored as correct or incorrect.

Table 6.4 shows the means and standard deviations for the Hyperlexic group and normal controls on this measure.

**Table 6.4- Decoding of Nonwords on the PALPA**

|                       | 3-LETTER          | 4-LETTER          | 5-LETTER          | 6-LETTER          |
|-----------------------|-------------------|-------------------|-------------------|-------------------|
| MEAN                  | H 5.5<br>NC 5.77  | H 5.5<br>NC 5.89  | H 5.6<br>NC 5.57  | H 4.7<br>NC 5.65  |
| STANDARD<br>DEVIATION | H 0.97<br>NC 0.71 | H 0.71<br>NC 0.43 | H 0.70<br>NC 0.90 | H 1.30<br>NC 0.85 |

H = Hyperlexic group      NC = normal control group

A one factor Repeated Measures Anova was conducted in order to explore the Hyperlexic group's reading of the 3, 4, 5 and 6-letter nonword stimuli of the PALPA nonword reading task.

Results revealed a significant difference between the different length words ( $F(1,9) = 3.228$ ,  $p < 0.05$ ). Related t Test results indicated a significant difference between the Hyperlexic group's reading of 3-letter versus 6-letter words ( $t = 2.44$ ,  $p < 0.05$ ), of 4-letter versus 6-letter words ( $t = 2.44$ ,  $p < 0.05$ ) and of 5-letter versus 6-letter words ( $t = 2.71$ ,  $p < 0.05$ ).

A number of previous studies have explored nonword reading in subjects with Hyperlexia (Aram, Rose and Horwitz (1984); Healy, Aram, Horwitz, and Kessler (1982); Frith and Snowling (1983); Goldberg and Rothermel (1984) and Siegel (1984). The majority identified strength in decoding of nonwords by subjects with Hyperlexia, a finding commensurate with this study.

Thus far it has been determined that the performance of subjects with Hyperlexia on the PALPA tests were broadly comparable with normal adults. Nonetheless, they did demonstrate that their reading was affected by imagery and frequency characteristics and they did exhibit a regularity effect seemingly evident for words that were unfamiliar to them (words of low frequency).

In examining the Hyperlexic group's decoding of nonwords, regular/exception words and words matched for frequency and imageability characteristics, we can conclude that the subjects with Hyperlexia can use either the visual or the phonological route to reading.

It is still possible however that they can read visually without accessing the meanings of words, ie. that they may be efficient at entering words in the Visual Input Lexicon regardless of whether they understood them. Normals may need to encounter the word much more frequently prior to entering the word into the Visual Input Lexicon and in this way normals may be more likely to recognise its meaning. This leads to the next theoretical hypothesis that will explore the accessing of meaning of printed words.

#### 6.5 Do subjects with Hyperlexia read words they don't understand?

In order to explore comprehension of printed words in more detail The Slosson Oral Reading -Test Revised was re-administered in modified format to six of the original subjects with Hyperlexia matched for chronological age with six of the original subjects with Dyslexia. The group size was reduced from ten to six subjects because some of the original subjects had moved away compromising their availability for continued participation in this project. The comparison group of children with Dyslexia was selected for this task for a number of reasons including that the two groups' receptive vocabulary skills had already been compared and found to be commensurate with one another, and their mirror image reading profiles previously identified.

Each subject with Hyperlexia was asked to read lists of twenty words containing phonically predictable and unpredictable patterns.

The words were presented in graded lists ie. lists corresponding to each grade level, and the most difficult list in which the subject obtained a score of fifteen or more correct was chosen for use in a comprehension task involving synonym selection. The subject with Hyperlexia was given a printed list corresponding to those words on the most difficult list that he or she had read correctly. Each word was accompanied by three options from which the synonym was to be selected, controlling for part of speech consistency amongst items.

The actual synonyms were randomly presented as option one, two or three. Subjects were required to underline the item of their choice that matched the target stimulus in the left hand column of the table. Responses were scored as correct or incorrect. It was expected that the Hyperlexic group would have difficulty showing understanding of complex words which they could read so efficiently. Each subject's chronologically age matched partner with Dyslexia was presented with the identical list for synonym selection.

However, given the overt struggle with reading of the subjects with Dyslexia, all words were read out loud to them while they could simultaneously follow along on the page in front of them. As with the subject with Hyperlexia, they were asked to underline the synonym that matched the word on the left hand side of the table. The task for the Dyslexic group focused exclusively on their ability to comprehend the single words that had previously proved too difficult for them to read so that they were not asked to decode the words.

The words chosen as stimuli were selected from items listed in a Thesaurus. The synonyms and decoys were verified by presenting a group of five normal American adults and five normal American adolescents the lists of words and asking them to complete the task. They responded 100% accurately to the task. The reader is referred to Appendix B for a list of the stimuli. Table 6.5 illustrates the numbers of items selected correctly and the percentage correct for each subject pair on the synonym selection task. The totals provided differ per pair and were dependent on the number of words the subject with Hyperlexia read incorrectly on their most difficult list.

Table 6.5- The Synonym Selection Task

| SUBJECT PAIR | TOTAL CORRECT | PERCENTAGE |
|--------------|---------------|------------|
| (H) W.H      | 9/15          | 66.67      |
| (D) J.R.     | 13/15         | 86.67      |
| (H) M.Dit    | 13/15         | 86.67      |
| (D) R.V.     | 9/15          | 66.67      |
| (H)E.J.      | 15/17         | 88.24      |
| (D) J.D.     | 11/17         | 64.71      |
| (H) S.Q.     | 11/15         | 73.33      |
| (D) D.M.     | 11/15         | 73.33      |
| (H) M.H.     | 13/15         | 86.67      |
| (D) A.S.     | 11/15         | 73.33      |
| (H) D.W.     | 14/16         | 87.50      |
| (D) J.W.     | 13/16         | 81.25      |

H =Hyperlexic group

D = Dyslexic group

H mean = 81.51

D mean = 74.32

The two groups were compared using related t test with no significant scores obtained ( $t=1.41$ ).

Results suggest that while the Hyperlexic group could decode complex vocabulary items accurately, they could also comprehend the same words. This finding is contrary to the initial prediction and leads one to question the manner in which the subjects with Hyperlexia approach the learning of novel words and whether insight into this process will help shed light on their complex symptom pattern.

#### 6.6 The Learning of novel written words

Age, gender matched normal controls were selected for this task because the task involved novel word learning and no longer incorporated standardised, normed information.

Furthermore, a novel word reading task would clearly represent a painful experience for children with Dyslexia and brought into question the ethical merits of their continued participation in such a project. It was predicted that the children with Hyperlexia would display supranormal ability to learn the novel words presented, and in order to identify the presence of supranormal skills it became imperative to compare the children with age matched peers. As such, five of the ten original subjects with Hyperlexia were selected to participate in this experiment and were matched with five normal peers from neighbouring school environments.

Once again the number of Hyperlexic children who participated in this section of the study was reduced as compared to the initial group of ten subjects.

Factors responsible for the reduction in group size related specifically to the reduced availability of subjects. All normal subjects were required to exhibit at least average nonverbal intelligence, normal hearing and display no history of learning, emotional or educational difficulties. The novel words introduced were controlled for regularity and semantic context cues.

Ten regular and ten irregular extremely low frequency words were selected from the Oxford Dictionary for use in the experiment. Each word was typed on a label and placed on a blue index card. The words were presented in random order. The first subject in each group received the words in one order, while the second subject received the list in reverse order. The lists were presented in an alternating fashion throughout the administration procedure. Subjects were presented with the words one by one and each word was read aloud by the examiner.

After a break of two minutes, the cards were shuffled and the subject was asked to read each word aloud to the examiner who scored them as correct or incorrect. Figure 6.6a represents the stimuli chosen for this task.

Figure 6.6a Stimuli for the reading of Regular and Irregular low frequency words

| REGULAR WORDS |         | IRREGULAR WORDS |          |
|---------------|---------|-----------------|----------|
| abate         | əbeɪt   | caulk           | kɔk      |
| accost        | ə'kɒst  | euchre          | 'ju:kə/  |
| beluga        | bə'lʊgə | fillet          | 'fɪleɪ   |
| dodo          | 'dɒdɒʊ  | gnaw            | nɔ       |
| edict         | 'ɪdɪkt  | heifer          | 'heɪfə/  |
| javel         | 'dʒævəl | larynx          | 'lærɪŋks |
| keek          | ki:k    | moire           | mɔə/     |
| scarab        | 'skærəb | oedema          | ə'di:mə  |
| nabs          | næbz    | phial           | 'faɪəl   |
| nape          | neɪp    | phasm           | fæzm     |

In order to investigate whether the provision of semantic context/picture cues would serve to hinder or facilitate the novel word learning of subjects with Hyperlexia, an additional feature of novel word learning was considered and another task component was devised using words that continued to be matched for regularity and frequency. It was hypothesised that the children with Hyperlexia would not take advantage of the semantic cues/referents provided. Ten regular and ten irregular words were therefore selected from the same Oxford List of extremely low frequency words. Each word was typed on a label and placed on a green index card.

A coloured picture that corresponded to each word presented was obtained from the New MacMillan Visual Dictionary and pasted on a large, white index card. Figure 6.6b presents the stimuli selected for the task. Subjects were shown the written word, heard it read aloud and were simultaneously shown the illustration of the semantic referent. The order of presentation was again counterbalanced so that the first subject in each group received the stimuli in one order and that order was reversed for the second subject and so on. After all the stimuli were presented, and a two minute break was provided, subjects were asked to read the words (shuffled again) to the examiner. Responses were scored as correct or incorrect.

Figure 6.6b Stimuli for the learning of low frequency regular and irregular picturable words

| REGULAR WORDS |          | IRREGULAR WORDS |         |
|---------------|----------|-----------------|---------|
| abacus        | 'æbəkəs  | scythe          | sɑɪð    |
| calyx         | 'keɪlɪks | thyme           | tɑɪm    |
| joist         | dʒɔɪst   | cuisse          | kwɪs    |
| gaskin        | 'gæskɪn  | fascia          | 'fæʃə   |
| dabber        | 'dæbər   | hyssop          | 'hɪsɒp  |
| incus         | 'ɪŋkəs   | charon          | 'ʃæron  |
| zither        | 'zɪðə    | phloem          | flɛm    |
| skeg          | skeg     | wapiti          | 'wɒpɪtɪ |
| vair          | veɪ      | jabot           | 'ʒæbɒʊ  |
| welt          | welt     | scotia          | 'skoʊə  |

Table 6.6a shows the means and standard deviations for the Hyperlexic group and normal controls when decoding the low frequency regular and irregular words presented without accompanying semantic/pictorial cues.

**Table 6.6a- Low Frequency Regular/Irregular Words (non-pictured)**

|                    | REGULAR WORDS        | IRREGULAR WORDS     |
|--------------------|----------------------|---------------------|
| MEAN               | H 9.200<br>NC 10.000 | H 6.400<br>NC 7.600 |
| STANDARD DEVIATION | H 0.374<br>NC 0.000  | H 0.812<br>NC 0.400 |

H = Hyperlexic group

NC = normal controls

Table 6.6b shows the means and standard deviations for each group when semantic/ pictorial cues were provided.

**Table 6.6b -Low Frequency Regular/Irregular Words (with semantic/pictorial cues)**

|                       | REGULAR WORDS       | IRREGULAR WORDS     |
|-----------------------|---------------------|---------------------|
| MEAN                  | H 9.400<br>NC 9.400 | H 3.800<br>NC 6.800 |
| STANDARD<br>DEVIATION | H 0.245<br>NC 0.400 | H 0.917<br>NC 0.860 |

H = Hyperlexic group

NC = normal controls

A 3 factor Analysis of Variance was conducted in order to investigate the Hyperlexic and normal control group's learning of novel printed words, presented with and without cueing. Group (Hyperlexic versus normal controls) were a between subjects variable while cues (yes/no) and words (regular/irregular) were within subject variables. A significant main effect was noted for group ( $p < 0.05$ ), cues ( $p < 0.05$ ) and words ( $p < 0.0001$ ). Results indicated that controls performed significantly better on this task than the Hyperlexic group. Surprisingly, the presence of semantic/pictorial cues significantly compromised performance in both groups and subjects read significantly more regular words correctly than irregular words.

Perhaps the extremely low frequency nature of the words selected, influenced the subjects' benefit from the semantic/pictorial cues.

If the words selected would have related more to the subjects' environment and were more relevant to their daily lives, the semantic/pictorial cues may have been more beneficial to them.

A nearly significant interaction of group by word type ( $p = .06$ ) was found indicating that it was the Hyperlexic group who had more difficulty with exception words.

In explaining the nature of the decoding strength in Hyperlexia it is imperative to investigate both accuracy and rate factors. Results from the GORT-3 certainly identifies significantly rapid reading rate. However, one cannot help but wonder whether their rate score was inflated by their lack of focus on the comprehension aspects of the task.

#### **6.7 Reading rate - is it truly unusual?**

In order to explore reading rate further, a task was devised devoid of a semantic focus. It was hypothesised that the rate of the children with Hyperlexia would be exceptional relative to the rate of the normal controls. All the subjects who participated in the novel word reading task also participated in this task.

Both the normal controls and the Hyperlexic group were explicitly informed that the words they would have to read were colour names, and that the task incorporated no comprehension demands.

Subjects were told that they had to read a series of colour names as quickly and as accurately as possible. All responses were timed using a stopwatch, and later scored as correct or incorrect.

Subjects were asked to read two pages of randomly presented colour names. See Appendix B.

Both the Hyperlexic and normal control groups produced no errors and their means for speed (reading rate) were 22.800 for the Hyperlexic group and 22.000 for the normal controls. This suggests that when you eliminate the semantic component from the reading process, the readers with Hyperlexia do not display a significantly rapid reading rate compared with the norm.

## 6.8 Decoding Success - A conclusion

This chapter has explored the nature of the Hyperlexic group's decoding strength. The chapter confirmed the hypothesis that the subjects with Hyperlexia can use all routes to reading effectively. In addition, it was established that their reading was affected by both imagery and frequency and that they displayed a regularity effect seemingly related to low frequency words. Although it was predicted that the Hyperlexic group may be able to decode complex words that they did not understand, it was determined that they could access the semantics of complex and even abstract vocabulary items which they read.

Given these findings it became fascinating to examine the manner in which subjects with Hyperlexia learn new words and the impact of insights in this area on our understanding of the decoding process for them.

As a result, novel decoding tasks were introduced to explore reading of regular and irregular words controlled for frequency and presented with and without accompanying semantic/pictorial cues. A regularity effect was noted and the Hyperlexic group did perform significantly more poorly than age matched normal controls. Furthermore, both groups' performance deteriorated when provided with accompanying semantic cues and it was proposed that the benefit of the semantic/pictorial cue was outweighed by the low frequency and relevance of the words to the subjects.

These findings suggested that the Hyperlexic group's reading skills were not as remarkable as originally thought, and overall results were disappointing in their limited ability to provide greater insight into the nature of the apparent decoding strength. Accordingly, the issue of semantics and reading competence was further explored in a task which removed the semantic component from the reading process. Results demonstrated that the Hyperlexic group's reading accuracy and rate were almost identical to the normal controls in this colour reading task. This implies that semantic elements of tasks may confound findings providing a false impression of unusual decoding strength.

Tasks such as the GORT-3 which require simultaneous focus on both reading rate and accuracy as well as reading comprehension may challenge normal controls who recognise the need for the simultaneous focus on both areas.

These same tasks may pose less of a challenge to the subjects with Hyperlexia who do not focus on the comprehension demands as required by the task. As such, the Hyperlexic group's significantly rapid reading rate on the GORT-3 may be accounted for by this factor rather than by a distinctly unusual decoding ability.

Overall, the results suggest that the Hyperlexic group are proficient readers who do not possess "unusual" decoding abilities on the tasks presented. On the contrary, their performance was unremarkable, and at times poorer, than age matched normal controls.

Perhaps the unusual decoding skills attributed to the Hyperlexic group were developmentally unusual in that they were normal skills that were available to them unusually early in life and as they grew older, age matched peers caught up with them so that at this time normal controls can perform as well if not better than them on the given tasks.

Although this theory seems appealing, it does not explain the Hyperlexic group's continued unusual performance on the GORT-3 which leads one to question the nature of the comprehension deficit identified in Hyperlexia and its impact on the reading process.

## Chapter 7 Theoretical Interpretations of Comprehension Breakdown

### 7.1 Comprehension breakdown and the subjects with Hyperlexia

The investigations have proved that in this study, the subjects with Hyperlexia can comprehend information presented at a word and sentence level. They can also comprehend factual and literal information presented in lengthier texts regardless of whether the tasks involve listening or reading comprehension. Nonetheless, they do exhibit significant comprehension breakdown on a text level that is suggestive of poor inferencing skills. This breakdown is evident on formal tasks, but is even more prominent in naturalistic and everyday contexts. This thesis has alluded to anecdotal information supporting weaknesses in pragmatics and inferential comprehension. The following example further illustrates this notion.

A burglary took place in the researcher's office at the Lab School of Washington. Two large windows had been shattered completely, a twenty-one inch television and VCR had been stolen, together with a large air conditioning unit that had been fitted into the window frame. Cupboards had been forced open, there was glass everywhere and the room was in complete disarray, when in walked one of the subjects with Hyperlexia. This subject, though very familiar with the researcher's office, as he had received twice weekly therapy in that space for the previous year, did not comment on any of this. He was asked for an opinion as to what he believed had occurred in the room. "You moved a piece of paper," he said.

When the burglary was discussed with him and the evidence jointly inspected he was asked, "How do you think the thieves came in?" He replied, "through the door of course!" although the evidence clearly suggested that they had shattered the windows in order to gain entry. This leads one to question what implications anecdotal evidence such as this has in our search for an explanation of the comprehension deficit evident in this group of subjects. We know that the understanding of real-life situations requires the integration of language with the context and intention of the speaker. In order to better understand the quality of the comprehension deficit specific to the subjects with Hyperlexia, theoretical explanations of success and failure in this process are described.

## 7.2 Language and Context

Chapman (1978) aptly explains how formal comprehension tests are usually designed to minimise contextual cues and general knowledge. In this way they typically are only mildly related to the child's ability to understand in everyday life situations. This can account for the mismatch frequently seen between scores on formal measures of comprehension and day-to-day functioning in the real world. Bishop (1997) asserts that as children grow older they continue to rely on information beyond the words they hear. This information may relate to long-term memory and knowledge of the world as well as information about the child's immediate physical environment.

Young children rely on their knowledge of what is probable in a given context as well as on how things typically behave or function (Bishop, 1997). General knowledge allows the child to resolve ambiguities by selecting the possible meanings of a given word and choosing the one that is most appropriate for the situation.

To do this effectively, the child needs to rely on background knowledge and integrate it with the spoken message. The child also needs to be able to make inferences about what is said in relation to what is probable in the situation. Bishop (1997) reminds us that competent communicators construct messages in such a way that they leave only the obvious unstated and they make explicit mention of things that the listener could not be expected to infer.

When we explore comprehension we cannot investigate knowledge of word meaning and syntactic structure exclusively. We need to go beyond these features to explore linguistic context as we do not react to each utterance in a conversation in isolation. Bishop suggests that we build up a representation of situations, events and objects and the relationships between these, and that we summarise all the information from the whole sequence. This allows us to encode the gist of the information and progressively add to this as the conversation continues.

Bishop cites a variety of early accounts of inferential processing that viewed language comprehension as the formation of a representation in propositional format, so that connected discourse is created by determining common elements in subsequent propositions (Kintsch and Van Dijk 1978). If no common elements are found, an inferential process has to be started with propositions that are implicit in the text added. Irrelevant and/or redundant propositions are eliminated to condense the set of propositions. Bishop does, however, caution that this type of approach does not adequately account for the richness of the representations that people derive from interpreting language in context.

This leads Bishop to suggest that meaning must be represented in a format more analogous to the real world, possibly using a "mental model". Instead of devising a set of interconnected propositions, it is suggested that we generate representations similar to our memories of experienced events in terms of their richness, subjectivity, fuzziness and multi modal nature. Although this type of mental model has much potential value, Bishop (1997) criticised it for its vagueness and the difficulty of incorporating it into formal accounts of comprehension.

Few studies have investigated the ability to interpret successive bits of information by forming mental models.

Karmiloff-Smith (1985) explored children's ability to produce narratives and showed that when they were asked to describe a story, shown in a series of pictures presented one at a time, four and five year olds tended to use pronouns to refer to something visible in the picture. Six to seven year olds used pronouns anaphorically to refer back to something already mentioned in the text, while eight to nine year olds used discourse relations in a more flexible manner.

Van den Broek (1989) emphasised that the ability to distinguish the central ideas or events in a story from those that are more peripheral is considered to be a major component of skilled reading. He explored whether children could use causal inferences as a basis for judging a statement's importance. Van den Broek presented subjects with a story containing three hierarchical episodes so that each episode was subordinate to the previous one. Causal relationships could occur both within an episode and between episodes in the story. Van den Broek found that children as young as eight years old could understand and use causal properties of statements to guide their comprehension of a text. Developmental differences were noted regarding sensitivity to different types of causal relations so that younger children were less influenced by interepisodic relations (connecting statements in different episodes) than older children.

Van den Broek cautions that this does not imply that young children cannot make inferences that connect episodes, but rather that they are less likely to do so as compared with older children. Studies have thus targeted coherence or the extent to which a text forms an integrated unit, as well as cohesion i.e. the use of anaphoric pronouns to refer back to something already mentioned in the text.

Bishop asserts that the conversational context adds a different dimension to discourse comprehension because it requires two individuals to collaborate in establishing and developing a topic. It involves appreciating the social role of language and necessitates the ability to integrate the current utterance with someone else's prior discourse. Bishop reminds us that research on conversations with children has not looked systematically at how mental models are developed.

Bishop adds that comparatively little work has been done on the use of contextual cues in comprehension by children with specific language impairment. It is suggested that discourse would be particularly problematic for children with specific language impairment given their probable limited processing capacity that would restrict the amount of information they could integrate.

Merritt and Liles (1987) compared language impaired and age matched control children on tasks of story generation, story retelling and story comprehension.

While comprehension of factual story details was similar in both groups, the language-impaired subjects were poorer on questions involving causal relationships that weren't directly stated. They concluded that problems with discourse cannot be simply reducible to secondary effects of fundamental limitations of sentence interpretation. Other studies found no evidence of a selective problem with inferences in children with specific language impairment (Crais and Chapman 1987).

Bishop and Adams (1992) utilised a story comprehension task to investigate children's comprehension of inferences. Subjects were presented with four or five pictures or photographs that corresponded to four different stories. A verbal version of each story was presented that briefly described each picture in the series and each story had two sets of accompanying questions, those that targeted literal information and those that involved inferential skills.

Bishop and Adams found that children with Semantic Pragmatic Disorder had lower scores than other children with Specific Language Impairment on this task and that they tended to provide more responses that suggested that they had not understood the given questions. Nonetheless, they found no indication that the subjects with Semantic Pragmatic Disorder had disproportionate difficulty with inferential questions in particular.

Although they had hoped that use of a task like this would reveal qualitative differences between subgroups of children with Specific Language Impairment, they found that, in general, children with Specific Language Impairment found the comprehension task difficult showing individual differences in quantity rather than quality.

Bishop highlights parallels between the findings from studies of Specific Language Impairment and results from studies investigating reading comprehension, showing that the comprehension problems of less skilled reading comprehenders extended to stories that were presented in spoken form with accompanying picture prompts suggesting that their difficulties were similar to those of children with Specific Language Impairment. Bishop concludes that it is rather unrealistic to expect children to do poorly on inferential questions while remaining unimpaired on literal questions, as, if you do not draw inferences, you will not form a long-lasting representation of the text as a whole and in this way your ability to answer all types of questions could suffer. These results highlight the methodological challenge of devising tasks which can adequately differentiate inferential problems and general comprehension difficulties.

Bishop proposes a number of explanations to account for problems with constructive comprehension in specific language impairment.

These explanations include the processing "bottleneck" that results when a child has to devote a great deal of attention to extracting meaning from individual words leading to problems in higher level comprehension. This would allow us to consider inferential problems of children with specific language impairment as secondary to more basic impairments. Results of research in this area have been inconsistent and complicated by the finding that discourse comprehension in children with specific language impairment is poor for both pictorial and verbally presented stories.

A second explanation is that of processing capacity limitations discussed previously, in which individuals have restricted processing abilities that impact the amount of information they can process and thereby comprehend.

A final explanation involves a failure to suppress irrelevant information. Kintsch (1994) stresses that if people use their general knowledge to make sense of what they hear or read, then we need to consider how they select what information is relevant and important. Bishop discusses studies on adults that reveal that during sentence processing a great deal of associated information is activated when a word is encountered. It is possible that items in long-term memory are automatically retrieved if they are linked to the text, but only remain activated if they can be integrated with the global text context. In this way irrelevant information simply decays because it cannot be integrated with prior information.

Gernsbacher (1990) suggests that a mental structure is built up as meaningful material is encountered and the structure is represented in memory cells. These cells are described as transmitting processing signals so that activation of those with related material are enhanced, while activations of those with unrelated materials are suppressed. When new material is encountered all related meanings are automatically activated and irrelevant meanings are quickly suppressed, so that the process is an active one.

Gernsbacher, Varner and Faust (1990) studied adults selected from samples of college students and air force recruits screened on a battery of comprehension tests. None of the subjects had Specific Language Impairment. Nonetheless, they differed in terms of their comprehension abilities and could be grouped as “more skilled” or “less skilled” comprehenders. Gernsbacher et al compared and contrasted the two groups’ performance on a task in which the adults read short sentences presented on a computer screen one word at a time. The subjects had to judge if a test word did or did not match the meaning of the sentence. In this way, the subjects would see a sentence on the screen and then either a related or unrelated word would appear. Half the trials included an ambiguous word as the final word in the sentence. The unrelated words provided did have an associated meaning with the ambiguous item, although they still needed to be rejected to successfully complete the task. They found a slowing in the time needed to make the judgement for a sentence with an ambiguous word relative to ones with neutral items.

Gernsbacher et al compared the reaction time to reject a word in an ambiguous versus a neutral context and noted that the amount of activation of irrelevant meanings was similar for skilled and less skilled comprehenders when the word was presented immediately after reading the sentence, but differed if a delay of 850 msec was imposed between reading the sentence and seeing the word.

They observed that the irrelevant meaning remained activated for less skilled comprehenders, suggesting that a critical characteristic of less skilled comprehension involves inefficient suppression of inappropriate or irrelevant information in the comprehension of both linguistic and nonlinguistic information. They concluded that persistent activation of irrelevant meanings prevent new information from being integrated within an existing structure and thereby encourages the development of unrelated structures destroying the overall cohesiveness of the text. The individual who does not suppress irrelevant meanings consequently builds mental structures that are bulkier, less cohesive and less accessible.

Although their subjects were adults who did not have specific language impairment, this finding may have some application to comprehension deficits in developmental populations. In fact, Bishop (1997) proposes that an inability to suppress irrelevant associations could help us understand some of the unusual phenomena observed in children with semantic-pragmatic disorder.

Bishop and Adams (1989) studied children with semantic-pragmatic disorder and found evidence of "topic drift" i.e. the production of utterances that may have some relation to the prior conversation, but which move off in an unexpected direction. This observation was virtually never seen in normal controls and can contribute to the impression of oddity frequently documented in those with semantic-pragmatic disorder. A failure to suppress irrelevant meanings is proposed to influence the tangential and irrelevant inferences that result.

This also has potential application to the current group of subjects with Hyperlexia who appear to have significant difficulty suppressing irrelevant information. Furthermore, people are more apt to process information they find interesting, and it has been proposed that individuals with Hyperlexia display intense interest in letters and print (Aaron 1989). Perhaps this intense interest could result in their focus on the decoding aspect of the reading task to the exclusion of a focus on meaning. This could reflect possible unexpected and unusual motivation perhaps influenced by a weakness suppressing irrelevant information, rather than a lack of comprehension ability in and of itself.

We do not know the underlying cause of the breakdown in comprehension in the current group of subjects with Hyperlexia. Perhaps the weakness relates to difficulty using contextual information appropriately or perhaps it involves a breakdown in the ability to suppress irrelevant information.

Later sections of this study will explore these notions further.

### 7.3 Understanding what is meant

While we know that we use general knowledge, environmental context and prior discourse as sources of information regarding meaning, we also need to address social context and the manner in which this is used to interpret messages.

At times, speakers use messages in which the literal and intended meanings are discrepant. For example a speaker may say, "Wow it's hot in here," implying, "Please turn on the air-conditioning," or, "Please open the window." This is an example of an indirect speech act showing that the intention is not equivalent to the logical, propositional meaning and the respondent is required to select the correct interpretation of the utterance when it could be interpreted in different ways. In fact, the speaker does not want the respondent to agree, "Yes, it is hot," so that selecting that literal interpretation would have meant that the communication would have failed.

To illustrate this further, here is another anecdote regarding one of the subjects with Hyperlexia. His teacher was handing out some barbecue chips and said to him, "Put these away in a safe place." He considered his pencil case as a place that was safe and placed the loose chips there. In making this choice he did not recognise the implications of placing loose chips in a pencil case filled with pencil sharpenings, lead and dirt.

The teacher required him to infer that he should select a place that would be safe and appropriate for storing food. This subject was devastated and shocked when he could not eat the chips later that day because he had misinterpreted her statement.

Theories have been proposed to explain how we are able to successfully understand what speakers intend. One such theory is Grice's (1975) co-operative principle that maintains that listeners recover the intended meanings by making basic assumptions about the co-operativeness of their conversational partner. Accordingly, a variety of maxims exist that guide communication. These include the maxim of quantity i.e., attempting to be as informative as possible; the maxim of quality, attempting to be truthful; the maxim of relevance, attempting to be relevant; and the maxim of manner, attempting to be brief and clear.

What Gricean theory fails to explain is how we are able to interpret the same utterance in the same context in different ways depending on the speaker. Bishop (1997) addresses this issue by discussing the critical importance of knowledge of the person's mental state in making an inference about their intention. In order to be successful we need to know what the person does or does not know as well as their emotional attitude.

For example, if person A says 'Are you going to the lecture tonight?' and person B says 'Person X is giving it again', we would need to know whether person B likes person X or not in order to understand his response.

Baron-Cohen (1995) calls this 'mind reading', the ability to deduce other people's mental states regardless of whether they are the same or different from one's own. In order to demonstrate pragmatic competence we need to be aware that other people have thoughts, beliefs, desires and knowledge. This awareness is termed Theory of Mind. Research has shown that a variety of factors contribute towards the development of Theory of Mind.

Bishop (1997) highlights three such factors that are important to consider because they may have implications for the comprehension breakdown evident in Hyperlexia.

The first factor relates to the child's ability to develop complex mental representations (in order to refer to absent entities or to consider imaginary events) that differ from representations that we use when we think of physical objects or events.

Problems forming complex mental representations could affect social comprehension and result in misunderstanding of the intents of others. Research in this area has shown some variability as children who possess a capacity for metarepresentation may not necessarily show understanding of others' mental states in a given experimental task.

As there are no pure Theory of Mind tasks, any given context may help or hinder the child's ability to demonstrate Theory of Mind. Specific Theory of Mind tasks will be presented in section 7.5 and discussed in detail in that section.

Theory of Mind is also dependent on the ability to interpret transient visual and vocal cues including facial expression, body language and prosodic features that signal meaning cues.

Research conducted by Bugental, Kaswan, Love and Fox (1970) showed that children as young as four or five could accurately interpret emotional tone from visual, vocal and verbal channels. Anecdotal evidence and background histories point to deficits in this area in the subjects with Hyperlexia.

Bishop adds that a competent communicator must be able to go beyond a general ability to infer mental states by analogy to one's own reactions, to develop a more sensitive differentiation between individuals so that one can understand the need to phrase one's message or interpret another's message differently depending with whom one is talking. We use social stereotypes or generalisations based on observable characteristics of the individual when determining how the person thinks and behaves.

We also use person specific knowledge in interpreting indirect speech acts. Social learning can be expected to play a part in the development of Theory of Mind as the more one interacts with others the more sensitive one might become to differences between them in terms of their beliefs, thoughts and emotions.

She concluded that effective communication therefore involves integrating linguistic knowledge with a general social understanding.

Individuals who fail to understand what others are thinking, who cannot identify differences between communicative needs of different people, who do not comprehend nonverbal cues to meaning, or cannot appreciate the normative behaviours of the culture in which they live, can be expected to have difficulty comprehending what people mean even when they may understand the propositional content of what is said.

McTear and Conti-Ramsden (1992) suggest that a child could be competent in one skill relevant to communication yet be deficient in others, or alternatively, a child could be competent in each of the relevant skills yet be unable to integrate them appropriately to serve the demands of communication.

This leads us to consider specific theories accounting for comprehension failure.

#### 7.4 Theories of Comprehension Failure

Bishop identifies three broad classes of explanation that have been put forward to account for comprehension failure.

Impaired information processing is one such explanation discussed previously. Accordingly, children may have problems integrating meanings from a series of sentences to form a coherent narrative.

As a skilled conversationalist, the person must be able to keep track of utterances over time and build a mental model that integrates features from all participants in the conversation. Clearly, a breakdown in this area could influence social interaction particularly when one considers the possible impact of lack of suppression of irrelevant information on a child's understanding.

The second explanation is that of an inadequate opportunity for social learning. Social communication problems, in this case, surface as secondary consequences of the distorted social experiences the child has had, given their language limitations. It is suggested that other children of the same age reject or neglect the child with the communication problem, because of their language limitations, and this results in the child ceasing to seek opportunities for social interaction and therefore gaining minimal experience of how others think and feel. It is however extremely problematic to be completely certain that the reason the child is rejected is not because of some basic impairment in social cognition coupled with their language problem or contributing to the manner in which their language problem is manifest.

Impairment of social cognition is the third explanation of comprehension breakdown and this together with the suppression of irrelevant information is considered relevant for the subjects with Hyperlexia.

Bishop discusses the DSM IV diagnostic categories and how they distinguish those with Specific Language Impairment from those with Autism.

Accordingly, DSM IV differentiates specific developmental disorders such as Specific Language Impairment indicative of impairment of functioning of a single domain with Pervasive Developmental Disorders including Autism in which abnormality is found in a greater number of functions. In this way, broad impairments of social communication that extend beyond weaknesses formulating and understanding language typically differentiate the two disorders.

However, Bishop suggests that there are children who do not fall neatly into either the Autism or Specific Language Impairment category because they do appear to have undue difficulty with the social aspects of communication and show some autistic-like behavioural oddities even though their problems are less severe than those seen in Autistic children and they generally correspond to those diagnosed with semantic-pragmatic subtype.

It is for this reason that Bishop proposes that an impairment in social cognition is relevant to Specific Language Impairment as there may be a small subset of children whose language problems are compounded by weaknesses in social cognition.

The possibility of such an impairment in social cognition is relevant to the Hyperlexic group's difficulties with everyday communication.

Consistent with symptoms found in those with Semantic Pragmatic Disorder we have seen that the current subjects with Hyperlexia use language which is not truly communicative (lacks the usual give and take of communication), that they appear impaired in their ability to encode meaning relevant to the conversational situation (tangential and irrelevant statements are made), that they are impaired in their ability to engage in communicative discourse (weak topic maintenance skills are documented) and that their comprehension of connected discourse is weak (inconsistent comprehension breakdown noted for connected discourse). All these observations point to the possible presence of a deficit in social cognition underlying their communicative breakdown.

A deficit in social cognition possibly involving Relevance (Sperber and Wilson, 1986) and/or Central Coherence (Happe, 1997; Frith, 1989a) could account for the comprehension breakdown in the subjects with Hyperlexia and are worthy of continued consideration.

Sperber and Wilson explain that humans have two ways of communicating. Consistent with views cited above, one form involves decoding and encoding messages in a more literal sense, while the other incorporates inferential communication in order to allow for the understanding of non-literal language such as idioms, metaphors and figures of speech. Communication is regarded as inferential because the audience is required to infer the communicator's intentions from their behaviour.

Sperber and Wilson suggest that all human beings automatically aim at the most efficient information processing possible. They provide the example of Mary and Peter sitting on a park bench. Peter leans back altering Mary's view. By leaning back he modifies her cognitive environment and reveals to her certain phenomena which she herself may or may not observe and describe to herself in various ways. They ask why people pay particular attention to one phenomenon as opposed to another and why they might describe it in one way or another.

Sperber and Wilson suggest that Mary processes the information most relevant to her at that specific time. Included among all the facts available to her is the fact that Peter behaved in a certain way. If she pays attention to his behaviour and decides it is deliberate, then she may ask herself why he chose to do that. Many possible answers exist.

Sperber and Wilson suggest that if Mary supposes he leaned back to attract her attention to a particular phenomenon then his specific behaviour has made it manifest to her that he intends to make some assumption manifest to her. This sort of behaviour (behaviour that makes manifest an intention to make something manifest) is referred to as ostensive behaviour. Sperber and Wilson emphasise that information processing involves effort, and the guarantee of Relevance makes it possible for Mary to infer which of the newly manifest assumptions have been intentionally made manifest.

Ostensive behaviour therefore provides evidence of one's thoughts, and succeeds because it implies a guarantee of Relevance. Accordingly, Sperber and Wilson define Relevance as an act of ostensive communication that communicates the presumption of its own optimal relevance.

Other universal features of the communication process are proposed. Happe (1994a) suggests that a characteristic of normal information processing seems to be a tendency to draw together diverse information to construct higher-level meaning in context. Frith (1989a) refers to this capacity as Central Coherence. She proposes that difficulties using context may stem from a failure of a central system that is responsible for integrating different sources of information to establish meaning. It is this universal feature of human information processing that Frith proposes is disturbed in Autism.

Accordingly, Happe (1997) suggests that normal individuals are constrained in their interpretation of information by the context in which the stimuli are presented, while subjects with Autism appear free from these contextual constraints. Therefore, she proposes that one clear prediction of the Central Coherence Theory is that people with Autism regardless of age or ability should be impaired at extracting context-dependent meaning.

Happe provides the following example to clarify the concept of weak central coherence.



Frith (1989a) predicted relative success for subjects with Autism when tasks required attention to local information or piece-meal processing and failure for tasks that involve recognition of global meaning and interpretation of individual stimuli in terms of overall context and meaning.

Jolliffe and Baron-Cohen (1999) explored local coherence (the ability to make contextually meaningful connections between linguistic information in short-term or working memory). They found that individuals with an autistic spectrum condition were impaired in achieving local coherence and had a preference not to strive for coherence unless instructed to do so or unless they made a conscious decision to do so. They also noted that this deficit in local coherence was not domain specific and involved both self-read and auditory material.

Frith and Snowling (1983) devised tasks that explored the ability of subjects with Autism to use context to disambiguate homographs to explore use of context. They presented sentences to their subjects and asked each subject for the correct pronunciation of given homographs. In order to pronounce the word correctly subjects had to select the context-appropriate pronunciation. Frith and Snowling compared subjects with Autism with subjects with Dyslexia and normal controls. They found that subjects with Autism tended to offer the more frequent pronunciation of the homograph regardless of the sentence context and consequently suggested that these subjects did not integrate meaning across a sentence to allow context-dependent processing of ambiguity.

While the Central Coherence Theory has been proposed to account for some of the severe impairments seen in children with Autism, Happe also suggests that this same theory allows us to explain the unusual strengths of Autism as well.

She advocates that both the unusual weaknesses and unexpected strengths could arise from a single characteristic of information processing. Accordingly, Happe (1994a) suggests that the Central Coherence Theory may be an explanation for viewing savant skills and suggests that these skills may be achieved through relatively abnormal processing, adding that abnormality would be evident in an abnormal and unusual error pattern.

Happe (1994a, 1997) offers the Block Design Test, a measure on which subjects with Autism easily succeed, as evidence for this theory. Frith (1989a) discusses how the Block design Test requires the individual to copy large designs using little building blocks. She suggests that the child has to separate the given design into appropriate segments in order to be successful on this task. Frith proposes that this has less to do with spatial ability and more to do with resisting the force towards central coherence in high level central thought processes. Accordingly, she remarks that if children with Autism show a weakness in central coherence they need not put up this resistance and the segmentation process would be easier for them. She also suggests that young normal children find The Block Design Test difficult because they cannot as yet control the high level central coherence force.

Consequently, it is proposed that the cognitive system of young normal children is different from that of children with Autism and is set up to operate with a strong central drive for cohesion.

If this is the case, Frith suggests that one can improve the performance of young normals by segmenting the task for them. Shah and Frith (1983) explored this area and confirmed that prior segmentation strongly improved the performance children with no autistic features but had little impact on able children with Autism.

This explanation provides evidence to suggest that both the assets and the deficits of Autism could potentially arise from a single cognitive level.

Furthermore, Happe (1994, 1994a, 1997) adds that Central Coherence may have application to the real-life symptoms of Autism and concludes that weak Central Coherence is a characteristic of even those subjects with Autism who possess some mentalizing capability. Frith (1989a) suggests that understanding social interaction is the ultimate challenge to our powers of Central Coherence noting that the normal operation of central coherence compels humans to give priority to understanding meaning so that we can single out meaningful from meaningless information.

She suggests that ordinary conversation and the understanding and answering of questions as intended by the questioner implies a striving for high-level global not only local coherence of information implying that weaknesses with high-level global coherence would likely influence the success of interaction in real-life communicative situations.

Jolliffe and Baron-Cohen (1999) confirm this viewpoint suggesting that a decreased ability to interpret information in context would negatively impact both comprehension and discourse coherence and that these difficulties would then disrupt communication ability and may partly explain pragmatic insensitivities.

Happe (1994a) explored whether a weakness in Central Coherence would limit the individual's ability to apply even intact Theory Of Mind appropriately in everyday life. Accordingly, in a study exploring Theory of Mind in more naturalistic contexts requiring subjects to extract meaning from a story context, she found that breakdown occurred whenever information from many sources needed to be integrated in context to provide the required input for mental state attributions. Accordingly, Happe concluded that a Theory of Mind mechanism which isn't provided with rich and integrated contextual information is of limited use for communication in everyday life situations.

Happe (1994a) suggests that the level of coherence may be relative so that within a given text there will be the word-to-word effect of local association, the sentence-context effect as well as the larger story-structure effect. She proposes that these levels may be disassociable so that when presented with open-ended tasks people with Autism may process the most local of the levels available to them. This prompted her to suggest that open-ended tasks be used to explore Central Coherence.

Furthermore, Happe (1994a) adds that it is likely that weak Central Coherence would be manifest in a non congruous processing preference in which the relatively local and piecemeal processing would be selected relative to the more global, larger-context meaning. This is in keeping with Frith's previously discussed viewpoint. Jolliffe and Baron-Cohen (1999) add that the finding of a deficit in integrating linguistic information at the local level must also occur at the global level. They suggest that because weak central coherence can be seen in diverse tasks it must stem from a deficit in central thought processes.

While Happe (1994a, 1997) notes that the Central Coherence Theory is still tentative and adds that it will take considerable research to empirically establish its contribution as a useful framework for thinking about Autism, the theory may have distinct applications to populations other than those with Autism. As such the theory warrants consideration relative to the current children with Hyperlexia.

Anecdotal evidence strongly indicates that the subjects with Hyperlexia may have difficulty interpreting the intents of their communicative partners indicating a possible Theory of Mind Deficit. Their conversational breakdown may also reflect a weakness suppressing irrelevant information (hence the need to consider relevance theory) and their discourse skills could suggest a breakdown in coherence suggesting the need to explore Central Coherence as it relates to the subjects.

How have these areas been investigated in the past and does this have implications for the current study?

## **7.5 Past Methods of Investigation**

Research in this area has involved three major methodologies. These are experimental work, conversational behaviour studies and use of checklist ratings. Experimental studies have been prominent in the literature and therefore will receive a major focus in this section. The majority of experimental studies have targeted the Autistic population.

### **Experimental Studies:**

A wide variety of experimental tasks have been devised to explore the prediction that individuals with Autism specifically lack a Theory of Mind and/or display deficits in Relevance and Central Coherence.

A limited number of these tasks will be presented in order to provide the reader with a framework from which to view the new tasks developed for this study and the novel situations specifically designed to explore higher level skills in this area.

The Sally-Ann task is perhaps most famous in the Theory of Mind literature. This false belief activity was originally devised by Wimmer and Perner (1983).

In this task the child is shown two dolls, Sally and Ann and watches the following scene as it unfolds. Sally has a basket while Ann has a box. Sally puts her marble in the basket and goes out for a walk. While she is out Ann (who is naughty) moves Sally's marble from the basket to her box and she goes out. Sally comes back and the test question, "Where will Sally look for the marble?" is asked. See Figure 7.5a for an illustration of this task as reprinted from Frith (1989a).

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### Figure 7.5a The Sally-Ann Task

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Wimmer and Perner found that children younger than age three and a half did not succeed on this task, while those aged four and over could complete the task successfully. Baron-Cohen, Leslie and Frith (1985) found that 80% of children with Autism who displayed mental ages over 4 failed to understand Sally's false belief task while 86% of those with Downs Syndrome with rather lower mental ages succeeded in this task.

A different Theory of Mind measure was devised by Perner, Frith, Leslie and Leekam (1989) who introduced "The Smarties Task", a task which required children to guess what a closed smarties tube contained.

Once the children had guessed that the tube contained 'sweets' or smarties, the tube was opened to show its true contents i.e. a pencil. The tube was closed and the children were asked the following question: "When Billy comes in I am going to show him this tube, closed up like I showed it to you. I'm going to ask him what he thinks is inside. What will he say?" Normal four year olds could recognise that Billy would have a false belief, while the Autistic children studied failed to recognise this.

Figure 7.5b illustrates this task, reprinted from Frith (1989a).

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**Figure 7.5b The Smarties Task**

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Other researchers have explored a variety of different forms of representation including use of nonmental representation such as pictures, photos and maps. One example of such a task is the "False Photograph task" devised by Leslie and Thaiss (1992). They compared understanding of an out-of-date belief with understanding of an out-of-date photograph.

The child was shown how to use a camera. Then he/she saw a character take a picture of a toy cat sitting on a chair. The instant photo was taken from the camera and placed face down on the table. In the meantime, the cat was moved to the bed. The test question, "In the photo where is the cat sitting?" was then asked. While less than 70% of normal 4 year olds passed this test 100% of subjects with Autism understood that the photo showed a no longer actual scene.

In contrast, the same subjects' performance was strikingly different on the Sally-Ann task (See Figure 7.5a) in which only 23% of the Autistic group (with mean age of 12 years and mean verbal age of 6 years) understood that Sally's belief was out-of-date. Happe (1994a) concluded that nonmental representations do not pose difficulty for Autistic individuals. Furthermore, she noted that their competence interpreting situations involving nonmental representations has also been illustrated using "false" maps and "false" drawings.

Figure 7.5c illustrates The False Photograph Task reprinted from Happe (1994a).

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**Figure 7.5c - The False Photograph Test**

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Several other experimental situations have been devised to explore Theory of Mind skills.

Perner and Wimmer (1985) devised "The John and Mary Ice Cream Story," later replicated by Baron-Cohen (1989).

Figure 7.5d illustrates the story in written and pictorial formats reproduced from Baron-Cohen (1989). This story in some ways influenced the novel tasks to be used for this study.

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Figure 7.5d - The Ice Cream Story - Baron-Cohen (1989)

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This is John and this is Mary. They live in this village.

*Naming Question: Which is John / Mary?*

Here they are in the park. Along comes the ice-cream man. John would like to buy an ice-cream but he has left his money at home. He is very sad. 'Don't worry,' says the ice-cream man, 'you can go home and get your money and buy some ice-cream later. I'll be here in the park all afternoon.....'. 'Oh good,' says John, 'I'll be back in the afternoon to buy an ice-cream'.

*Prompt Question [1]: Where did the ice-cream man say to John he would be all afternoon?*

So John goes home. He lives in this house. Now, the ice-cream man says, 'I am going to drive my van to the church to see if I can sell my ice-creams outside there'.

*Prompt Question [2]: Where did the ice-cream man say he was going?*

*Prompt Question [3]: Did John hear that?*

The ice-cream man drives over to the church. On his way he passes John's house. John sees him and says 'Where are you going?'. The ice-cream man says 'I'm going to sell some ice-cream outside the church'. So off he drives to the church.

*Prompt Question [4]: Where did the ice-cream man tell John he was going?*

*Prompt Question [5]: Does Mary know that the ice-cream man has talked to John?*

Now Mary goes home. She lives in this house. Then she goes to John's house. She knocks on the door and says 'Is John in?'. 'No,' says his mother, 'he's gone out to buy an ice-cream'.

*Belief Question: Where does Mary think John has gone to buy an ice-cream?*

*Justification Question: Why?*

*Reality Question: Where did John really go to buy his ice-cream?*

*Memory Question: Where was the ice-cream man in the beginning?*

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**Figure 7.5d - The Ice Cream Story - Baron-Cohen (1989)**

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Researchers have also explored understanding of people's wrong beliefs using co-operative and competitive story versions (Wimmer and Perner 1983). Wimmer and Perner suggest that deception action is a good way of demonstrating the presence of Theory of Mind because it requires the conceptualisation of the deceived person's wrong belief as a subgoal in one's planning strategy. They presented children with two stories and each story had two versions. In one version they made it obvious that the protagonist wanted to co-operate with another character to obtain a hidden object. The other version of the story showed a protagonist competing with the antagonist.

To illustrate this concept they provide the example of a little girl in kindergarten who hid her favourite book. While all the children went out for a walk a caretaker reshelfed the book. When the class returned from their walk a second character is introduced. The cooperative version shows this character as the girl's friend to whom she offers to show her book and she tells him where to find it. In the other version there is another child looking for the book and the little girl attempts to mislead him.

The children were asked memory, reality and belief questions following the stories.

Wimmer and Perner found that understanding of another person's wrong belief requires explicit representation of the wrongness of the person's belief in relation to one's own knowledge.

They concluded that a novel cognitive skill emerges within the 4-6 year old age range that allows children to represent wrong beliefs and construct a deceitful or truthful utterance relative to a person's wrong belief. Notions of deceit, lying and sabotage have been explored experimentally by Sodian and Frith (1992) and will be further explored in this study.

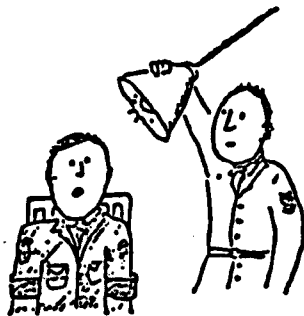
Finally, experimental tasks have also been devised in order to investigate more advanced Theory of Mind skills. As discussed above, Happe (1994) aimed to extend the range of tasks involving Theory of Mind to incorporate a more contextually embedded and realistic representation which might challenge those subjects who succeeded on simplified tasks but still exhibited weaknesses in everyday life situations. She utilised twelve types of stories in which people say things they don't mean literally, for one of the following effects: lies, white lies, jokes, pretence, misunderstanding, persuasion, appearance and reality, figures of speech, sarcasm and double bluff. Six control 'physical' stories were also given to subjects who were either Autistic, mentally handicapped or normal controls. The physical stories did not target mental states but focused rather on unforeseen outcomes with a mechanical or physical cause.

Figure 7.5e illustrates two examples of Happe's stories.

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Figure 7.5e - Examples of Happe's (1994) Advanced Theory of Mind Studies (The Strange Stories)

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*Story type: Double Bluff*

During the war, the Red army capture a member of the Blue army. They want him to tell them where his army's tanks are; they know they are either by the sea or in the mountains. They know that the prisoner will not want to tell them, he will want to save his army, and so he will certainly lie to them. The prisoner is very brave and very clever, he will not let them find his tanks. The tanks are really in the mountains. Now when the other side ask him where his tanks are, he says, "They are in the mountains".

Is it true what the prisoner said?

Where will the other army look for his tanks?

Why did the prisoner say what he said?



*Story type: Persuasion*

Jane wanted to buy a kitten, so she went to see Mrs. Smith, who had lots of kittens she didn't want. Now Mrs. Smith loved the kittens, and she wouldn't do anything to harm them, though she couldn't keep them all herself. When Jane visited she wasn't sure she wanted one of Mrs. Smith's kittens, since they were all males and she had wanted a female. But Mrs. Smith said, "If no one buys the kittens I'll just have to drown them!"

Was it true, what Mrs. Smith said?

Why did Mrs. Smith say this to Jane?

Happe found the stories revealed deficits in social understanding in even the most able subjects with Autism who had passed a range of Theory of Mind tasks. She hypothesised that the more naturalistic format of the stories and the absence of test questions drawing attention to salient elements may reveal the weaknesses that even the most able individuals with Autism may have weaknesses in applying their social knowledge to everyday life.

Participants included one group of subjects with Autism who seemed to lack mentalising ability, others who passed only first-order Theory of Mind tasks while still others who passed second-order tasks as well. Happe found that while the subjects with Autism gave as many mental state responses as controls, they used mental state terms that were not appropriate for the given contexts. The three groups performed differently on the story tasks with the second-order Theory of Mind group obtaining the highest number of correct responses.

Bowler (1992) conducted a study of subjects with Asperger's syndrome focusing on their ability to solve problems requiring first and second order Theory of Mind (i.e. awareness of not just one person's belief, but also one person's belief about another person's belief).

Figure 7.5f presents the "Peter and Jane" story used by Bowler (1992).

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Figure 7.5f - "The Peter and Jane Story" - Bowler (1992)

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Peter and Jane are out shopping on their lunch hour. Peter wants to buy an overcoat and the nicest one he has seen is at Store X. But before he makes up his mind, he would like to go to Store Y to see what they have in stock. So they both go to Store Y where they look at some coats. These are not as nice as the ones at Store X, so Peter decides to go back to Store X that evening after work to buy his coat.

**Prompt Question 1:** Where has Peter decided to buy his coat?

**Prompt Question 2:** When?

Peter and Jane agree to meet at Peter's office at 5.15 that evening to go to Store X.

**Prompt Question 3:** Where have Peter and Jane agreed to meet?

**Prompt Question 4:** Where have they decided to go?

At 5.00 that afternoon, Peter phones Store X to make sure that they have a coat of his size still in stock. Unfortunately, they tell him that they have just sold the last one and that they don't know when they will be getting any more in.

**Prompt Question 5:** Does Peter now know that Store X are out of stock?

**Prompt Question 6:** Does Jane know that Peter has phoned Store X?

By 5.20 Jane has not arrived at Peter's office, so Peter decides that he had better go alone to buy his coat before the shops close.

At 5.25 Jane arrives at Peter's office. She is late because she popped in to Store X on her way and found out that they had no more of the coats that Peter liked in stock.

**Prompt Question 7:** Does Jane now know that Store X are out of stock?

Peter's secretary tells Jane that he has already gone out to buy his coat ....

**Test Question:** Where does Jane think Peter has gone to buy his coat?

**Justification Question:** Why?

**Reality Question:** Where has Peter really gone to buy his coat?

**Memory Question:** In which shop did Peter see the coat he liked the best?

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Other researchers have investigated additional issues thought to impact social cognition. Happe (1993 and 1995) explored the principle of Relevance i.e. that every act of ostensive communication conveys a presumption of its own optimal relevance. Happe discusses the fact that there are many situations in which a speaker aims at optimal relevance and may not utter a literal formulation of his or her thoughts. The principle of Relevance then allows one to decide which assumptions are warranted and what meaning was intended.

Happe (1995) studied the connection between understanding of similes, metaphors, and irony by children with Autism and explored whether these skills could be closely associated with the children's level of Theory of Mind ability. Consequently, she suggests that metaphors cannot be fully understood with a first-order Theory of Mind because they require understanding of intentions and recognition that the propositional form of the utterance is a potentially loose interpretation of the speaker's thought. Sperber and Wilson (1981) assert that irony is even more demanding requiring an understanding of second-order mental states in order to attribute a thought about a thought.

The subjects with Autism who participated in this study were grouped according to their competence in Theory of Mind and were the same subjects who completed the Advanced Theort of Mind tests involving the "Strange Stories."

Accordingly, six of these subjects failed all Theory of Mind tasks, a further six passed first-order tasks, whilst the last six passed second-order tasks. She found that the three groups' performances on the figurative language tasks could be predicted from their performance on initial Theory of Mind tasks. Happe suggests that the communication problems of those with Autism share a common cause involving the inability to attribute mental states to others.

The existence of subjects who were able to pass Theory of Mind tasks but continued to exhibit social and communication handicaps in everyday life led to the need to explore the relationship between a breakdown in Central Coherence and an inability to use context cues to aid comprehension using homograph disambiguation tasks.

Happe (1997) suggested that weak coherence is a characteristic of all individuals with Autism, regardless of their Theory of Mind abilities and proposed that a deficit in Central Coherence can co-exist with a degree of Theory of Mind competence. She also proposed that weak coherence may be a persisting feature of those with Autism who have Theory of Mind ability albeit perhaps delayed. She demonstrated this using a homograph reading task. Jolliffe and Baron-Cohen (1999) later explored Central Coherence in adults with autistic spectrum conditions.

They conducted three different experiments including a Homograph Test (in which participants had to spontaneously give the context-appropriate pronunciation of a homograph. For example, "*It was lead in the box that made it so heavy*", or, "*The man had a second row with his wife*"). Their second experiment was The Local Coherence Inference Test in which participants had to select an intervening statement which best fit to make two other statements coherent. For example: *George left his bathwater running. George cleaned up the mess in the bathroom. George cleaned up the mess in the bathroom because: the bath had overflowed, his brother had left it untidy, the workman hadn't cleared up his mess.* The third experiment was the Ambiguous Sentences Test in which subjects had to integrate an ambiguous sentence with its context in order to select the context-appropriate interpretation of the ambiguous sentence. For example: *John went to the art class. He drew a gun. What did John do? —pull out a gun, draw a picture of a gun, shoot from a gun.* Results from their study indicated a deficit in achieving local coherence as discussed above.

A limited number of studies have explored Theory of Mind and related skills of Relevance and Central Coherence in children with Semantic-Pragmatic Disorder and Specific Language Impairment. Bishop and Adams (1992) found that these children could appreciate another's false beliefs provided they were questioned about these beliefs using simple language.

Studies have not however thoroughly explored Relevance and Central Coherence in non-Autistic populations. Possible breakdown in this area has particular application to the symptoms displayed by the subjects with Hyperlexia.

If a child passes a false belief test, it does not imply that the child will always be able to infer other people's mental states correctly. Bishop proposes that the structure and concrete setting provided by experimental tasks helps children compensate for underlying problems in using contextual cues. This seems very important for the subjects with Hyperlexia whose language skills in highly structured and more concrete situations appear stronger than those which are displayed in everyday life contexts.

Chapters 8 and 9 will consider the types of experimental tasks which will offer the greatest insight into the nature of breakdown observed in the subjects with Hyperlexia.

#### Conversational Behavioural Rating Scales:

The second methodology used to explore understanding of intended meaning is that of conversational behaviour ratings used to investigate conversational skills in ways which standardised tests cannot. Bishop, Chan, Adams, Hartley and Weir (in press, 1998) document the need for the development of new methods for quantifying and characterising pragmatic difficulties in conversation.

A number of studies have recently emerged in this regard. One such study is that of Adams and Bishop (1989) who investigated children with Specific Language Impairment both with and without characteristics of Semantic-Pragmatic Disorder using conversational data obtained in semi structured situations in which specific topics were introduced using photographs as prompts and children were encouraged to talk about their own experiences.

Adams and Bishop explored utterances according to whether they were initiations, responses or follow-ups to the adult input. They found that the Semantic-Pragmatic Group demonstrated an unusually high rate of initiations. It appeared that it was not how much the child said but rather the extent to which they took the conversational lead that frequently led to the conclusion that children with Semantic-Pragmatic Disorder were verbose.

Later, Bishop and Adams (1989) used data from the original study to try to pinpoint the factors that gave rise to impressions of oddity in conversations by scrutinising interactions for indications of inappropriacy. They found that those with Semantic-Pragmatic Disorder did produce an overall higher percentage index of inappropriate responses but that no children produced contributions that were completely bizarre and that the inappropriate utterances usually resulted in a temporary glitch in the conversation rather than a sense of total disruption.

Subjects with Semantic-Pragmatic Disorder were noted to provide too many details at times, whilst at other times they provided too few. They tended to be poor at judging what other people knew or didn't know.

Bishop et al (in press, 1998) also obtained conversational data from children with Specific Language Impairment, those with Semantic-Pragmatic Disorder and normal controls.

Consistent with the prior studies, conversational data were obtained in semi-structured situations in which specific topics were introduced using photographs as picture prompts.

The children were encouraged to talk about their own experiences but this time the children's responses were compared and analysed according to whether the soliciting utterance of the adult was responded to by the child, whether the children used nonverbal response styles and the quality of their responses.

Bishop et al hypothesised that younger normal children would be less responsive to adult solicitations than older normal controls, that those with typical speech and language impairments would be less responsive to adult solicitations than age matched normal controls but that they would not differ from language matched controls. Those with pragmatic language impairment were expected to show a lower level of responsiveness when compared with younger normal controls.

Children with limited language skills were predicted to show a tendency to respond nonverbally except for those with pragmatic language impairment. It was also expected that younger normally developing children would give fewer adequate responses to adult solicitations as compared with older normal controls but that they would not produce a high rate of pragmatically inappropriate responses.

Finally, it was anticipated that those with typical Specific Language Impairment would resemble younger normally developing children in the quality of their responses while those with pragmatic language impairments would display a higher rate of pragmatically inappropriate responses.

Bishop et al found differences in the response pattern of younger language-age matched controls and older chronologically-aged matched controls. The most marked differences between the groups related to use of nonverbal responses. They found that children (regardless of age) were more likely to use nonverbal responses for acknowledgement-soliciting utterances than information-soliciting utterances, but that younger children relied more heavily on nonverbal responses. They also found that what changes with age is not the likelihood of responding but the form the response takes.

Younger control children were more likely than older children to fail to give an adequate response to an adult solicitation, although their responses tended to fall into the “inadequate” category rather than being judged as “pragmatically odd”.

Bishop et al also noted that, on average, children with Specific Language Impairment were less responsive to adult solicitations than chronologically-aged matched controls.

Those with pragmatic impairments displayed an even higher rate of non-responding than language -aged controls, suggesting that variation in responsiveness was not purely a consequence of limited mastery of language structure. Language Impaired children, especially those with pragmatic impairments, also tended to have a low rate of nonverbal responses and several did not use this response mode at all, a response pattern unlike younger normally-developing children. Furthermore, children with Specific Language Impairment generally had a lower rate of adequate responses than either control group regardless of subtype of Language Disorder.

They added that many of the responses of Language -Impaired children which were coded as “not adequate” were also pragmatically inappropriate and could not be readily explained in terms of poor comprehension or limited verbal formulation skills.

They noted a striking relationship between the tendency to produce pragmatically inappropriate responses and a low level of nonverbal responses. Their findings led them to conclude that conversational skills are not invariably a strength of children with Specific Language Impairment suggesting that while many language impaired children may simply be immature in their conversational behaviour, there is a subgroup of children who have broader communicative impairments influencing their conversational skills.

Bishop (1997) stresses that while evidence from conversational data may be indirect, it does offer tentative support to the notion that some children may have pragmatic difficulties that are associated with subtle impairments of social cognition. Nonetheless, features complicating conversational behaviour studies include the need for independent raters to verify findings as the results are more susceptible to subjectivity, and the need for a high level of specificity of criteria to categorise findings and observations.

#### **Checklist Ratings:**

The final methodology used to target this area is that of checklist ratings. Bishop (in press, 1998) discusses the various methods that can be used in assessment and their relative advantages and disadvantages.

The Children's Communication Checklist developed by Bishop builds on a series of studies that extended over time to assess aspects of communicative impairment not adequately evaluated by contemporary standardised tests. She concluded that this particular checklist looks promising as a tool for both research and clinical practice. Checklists represent quick and efficient ways to gather information, they can provide a representative indication of a typical behaviour for a child and can allow one to assess behaviours that are difficult to elicit in test situations. Nonetheless, rating scales used in checklists are more prone to subjective interpretations than formal measures.

We can conclude that there are advantages and disadvantages to all three types of methodologies.

Although experimental tasks have been widely used to identify social cognition deficits in Autism, they have been less widely used to study social cognition in Specific Language Impairment. While alternative methodologies including studies of conversational behaviour and checklist ratings have emerged and have been used to explore skills of children with language impairments, these too have their limitations, suggesting the need for further refinements to all three types of methodologies.

## **7.6 Comprehension Failure - A Conclusion**

The literature on comprehension and comprehension failure leads us to conclude that use of contextual information, social cognition skills, ability to suppress irrelevant material, capacity for Theory of Mind and Central Coherence all contribute towards our ability to comprehend information. A range of experimental studies have been devised to explore these areas which may throw some light on the deficit thought to underlie the comprehension breakdown in Hyperlexia. In looking at the types of errors made by the subjects with Hyperlexia on the Gray Oral Reading Test-3, one is struck by an apparent difficulty recognising the knowledge and feelings of other characters in the text. Experimental tasks that appear to have the most application to the subjects with Hyperlexia include Happe's (1994) Advanced Theory of Mind Stories and Bowler's (1992) "Peter and Jane" Story. They offer us a starting point for the development of original social cognition tasks.