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## Literacy development in children with cerebral palsy

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**'Literacy Development in Children  
with Cerebral Palsy'**

Submitted for Doctorate of Education

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**The Open University**



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## ABSTRACT

This thesis concerns the literacy difficulties of fifteen children with cerebral palsy (CP). The children were an opportunistic sample from two schools, and were initially selected on the basis that they had typical abilities in other school subjects.

A review of the literature pertaining to the development of literacy and related aspects of cognitive development in typically-developing children and children with CP informed the development of the research strategy.

The children's literacy, their general non-verbal and communication abilities, as well as a set of cognitive abilities that could be related to literacy impairments, were assessed.

The findings revealed that most, but not all, of the children with CP had literacy difficulties with low scores in reading and spelling, and all the children had problems with handwriting. Standardised assessments showed that while the children had good verbal abilities, they had very low scores on a non-verbal test.

The children with the most severe literacy difficulties also had the most problems with phonological processing. Almost all of the children had difficulties with visual and spatial perception; however the better readers had typical results in an assessment of visual sequential memory. Tests of working memory (WM) revealed a clear division between typical levels of performance on verbal recall measures, and very poor performance on the visual components of working memory tests. There were mixed results for the assessment of the central executive, but generally those children who were the more able in literacy had higher scores.

Correlations suggested that visual sequential memory; phonological segmentation; verbal recall; and aspects of the central executive of working memory were most closely associated with the children's literacy abilities. Thus, the findings indicate that children with CP have specific cognitive impairments, including a new suggestion that poor visual sequential memory abilities could delay the development of reading and spelling skills.

## Chapter 1

### 1.1: Introduction to the thesis

After teaching in mainstream schools both as a class teacher and a special needs tutor and SENCO (Special Needs Coordinator), I went on to teach in special education. I first taught in a primary school for children with moderate learning difficulties, specialising in the teaching and the inclusion of children with autistic spectrum disorders. I later moved to my present school which is a school for children with physical disabilities. The ages of the students in the school span from three years to nineteen years, and many have quite complex difficulties as well as a physical disability, including learning disabilities, visual impairment, and speech and language difficulties.

My first class was vertically grouped, Years 1, 2 and 3 with the children ranging in age between five and eight years. It was made up of ten children – five boys and five girls, of whom seven had cerebral palsy (CP). Most of the children were in the average to low average ability range and it appeared that it was only their physical disabilities that were preventing them from being placed within mainstream schools. Indeed, six of the children had inclusion programmes whereby they went into mainstream schools local to their homes for one or two days a week, with a view to possible future full time placement.

However, it soon became apparent that the children, particularly those with cerebral palsy, were having difficulty learning the alphabet, both the names of the letters and their sounds. They also had difficulty with remembering common words such as 'the', 'and', 'we' that they regularly encountered in their graded reading books. In addition, they had many problems with overwriting or copying individual letters, which was to be expected due to a lack of coordination in their hands, but they seemed to have difficulty in following the general shapes of the letters. It was as if they were unable to perceive their forms

properly. The children had the same difficulties with writing numbers particularly 2, 3 and 5. All of these problems might be encountered in children who have general learning difficulties, but the children with CP appeared to have few problems learning subjects such as Science and History when analysing and problem solving were required rather than literacy ability.

Talking to other teachers in the school about the children's literacy difficulties was illuminating as they too had children with CP in their classes who had similar problems with reading and spelling, particularly with phonological awareness. I tried to look for information regarding CP and difficulties with literacy, but could find very little as most research on CP seemed to focus on physical disabilities and therapy.

Using the Bangor Dyslexia Test (Miles, 1997), I tested one of the boys in my class as part of a Master's degree case study and his results indicated that he had specific difficulties found in children with dyslexia involving sequencing, repeating words and backward digit strings, and problems with identifying phonemes particularly vowel sounds. Further testing revealed that other children with CP in the class also shared these difficulties. I wanted to further my knowledge and understanding of the cognitive factors that affected the literacy skills of children with CP and decided to research the subject by way of an educational doctorate.

Observing the pupil's difficulties in learning to read and write gave me some indications of the areas of research literature I needed to examine. Using google scholar and the OU library online search facility I searched for the key terms cerebral palsy and literacy but found very little, so I widened my search (with no limit to publication date) to reading difficulties, spelling difficulties and writing difficulties together with cerebral palsy. The

widest range of literature regarding CP and literacy concerned children with speech and language impairments who were AAC (Augmentative and Alternative Communication) users.

My previous research suggested that the children with CP, who I had assessed, seemed to have difficulties similar to those of children who had dyslexia. I therefore examined studies regarding dyslexia (Snowling, 1987; Frith, 2002; Snowling and Hulme, 2005) to see if there were commonalities between children with dyslexia and children with CP. This gave me a starting point and led to the concept of assessing more children with CP to identify whether they too had specific literacy difficulties and/or associated cognitive difficulties. As mentioned, the children with CP in my class all seemed to have difficulties with print, both the writing and decoding of letters, and remembering common words that they encountered in their reading books. However, the studies regarding the therapies used for children with CP indicated other issues such as difficulties in visual perception (Koeda, Inoue and Takeshita, 1997) and spatial awareness (Pueyo, Junque, Vendrell, Naberhaus and Segarra, 2009) which might also influence the development of literacy skills (Straub and Obrzut, 2009). Therefore, the question was raised as to whether children with CP, who can speak, have specific cognitive difficulties or a specific profile of impairment, which relates to their apparent difficulties in developing their literacy skills.

The following literature review is designed to investigate the general question and to develop further questions and methodology for an in-depth study. Beginning with an examination of typical literacy development, and then an exploration of issues concerning children with CP, the review consists of the following:

- literacy development in typical children;
- children with cerebral palsy, a description of the condition;

- phonological processing in typical children and children with CP;
- visual and spatial perception difficulties and literacy development;
- working memory and literacy development.

The last section of the chapter contains an outline of the research methodology pertaining to the five studies contained within the thesis on a group of fifteen children with CP.

### **1.2: Literacy development in typical children**

Many studies and reviews have been devoted to the cognitive processes involved in the development of literacy particularly reading (Marsh, Friedman, Welch and Desberg, 1981; Frith, 1985; Ehri, 2002; Ehri and Snowling, 2004, Hulme and Snowling, 2009). Researchers have used different models to present their theories of the development of reading using stages or phases to describe the progression of knowledge (Ehri, 2005). Ehri has published this summary (Figure 1.1) to explain how the different theories compare.

Several researchers refer to an implicit or pre-reading stage or phase where children can recognise words or logos which have an emotive context, e.g. their own names, a favourite café or a cartoon character (Frith, 1985; Ehri, 2002) but will have little or no knowledge of letters. Researchers have investigated the kind of cues which are used by children to remember words in their environment such as the colours and shapes of letters and words used in logos (Sheehy and Holliman, 2009). If the visual appearance is changed in any way (Ehri, 2005) children are often unable to recognise the word.

Figure 1.1: Theories of developmental models of reading (Ehri, 2005, Page 139)

Proponents	<i>Gough &amp; Hillinger (1980)</i>	<i>Mason (1980)</i>	<i>Marsh et al. (1981)</i>	<i>Chall (1983)</i>	<i>Frith (1985)</i>	<i>Ehri (1998, 1999, 2002)</i>	<i>Stuart &amp; Coltheart (1988)</i>	<i>Seymour &amp; Duncan (2001)</i>	
Number of Developmental Periods	2	3	4	5	3	4	2	4	
1. Pre-reading	↑ Cue reading ↓	Contextual dependency	Rote, linguistic guessing	Stage 0: Letters/Book exposure	Logographic	Pre-alphabetic	↑ Partial orthographic ↓ Complete orthographic	Pre-literacy	
2. Early reading		Visual recognition	Discrimination net guessing	Memory and contextual guessing		Partial alphabetic		Dual Foundation	
3. Decoding	↑ Cipher reading ↓	Letter-sound analysis	Sequential decoding	Stage 1: Decoding, attending to letters/sounds	Alphabetic	Full alphabetic	↓ Complete orthographic ↓	Logographic	Alphabetic
4. Fluent reading			Hierarchical decoding	Stage 2: Fluency, Consolidation	Orthographic	Consolidated alphabetic, Automaticity		Orthographic	Morphographic

Secondly, there is a phase or stage where children start to recognise and learn some letters and develop some phoneme/ grapheme representations (Marsh et al, 1981; Ehri, 2002), particularly initial letters, for example, children may recognise the initial letter of their own names in other words. Often children are unable to remember whole words at this stage (Ehri, 2005) unless they have a distinctive shape or they are in a specific context, such as names above coat pegs.

In the third stage or phase, children develop more stable representations of phoneme/ grapheme associations and can begin to decode by sounding out individual letters such as in cvc words. This stage is called the alphabetic (Frith, 1985) or the full alphabetic (Ehri, 2005) or sequential decoding (Marsh et al, 1981). Children have to go through a process where they learn to recognise that as well as sounding out the individual letters they need to join the sounds together to make a word (Ehri, 2005). Researchers differ in their opinions about this stage (Ehri, 2005) as to whether children use visual cues or phoneme/ grapheme strategies to decode, and this may depend on teaching methods in schools or at home, but Frith (1985) suggests that children's early writing and spelling skills support the development of letter/ sound skills and promotes the association between word-sight reading and sequential decoding (Marsh et al, 1981).

In the fourth phase or stage, children begin to develop more connections between sections of words such as syllables and morphemes (Ehri, 2002) with the consolidation of analogy, and orthographic spelling and decoding (Marsh et al, 1981; Frith, 1985). Alongside the decoding of phonemes and syllables into whole words, children will also be developing a lexicon of sight-words, which is extremely important as many of the more commonly-used words in the English language are not phonetically regular. Fluent readers tend to read



whole words by sight rather than by decoding (Ehri and Snowling, 2004; Ehri, 2005), and real words are read much faster than nonwords, which still have to be decoded.

Comprehension of text is as important as its decoding in the development of reading (Nation, 2005; Hulme and Snowling, 2009). Some children can be relatively able in one skill but not the other, but both are essential. Some teachers and curriculum designers in a 2003 report by Brown (cited by Ehri, 2005) suggested that children, when being taught to read, should just be given texts to decipher and should not rely on picture cues or context; however this seems to miss a significant part of reading which is for enjoyment as well as the development of skills and knowledge (Smith, Smith, Gilmore and Jameson, 2012). This is important as many children who struggle with learning basic skills in reading find it difficult to enjoy literacy because all their attention is given to decoding rather than enjoying or understanding the meaning of a text (Apel, 2009). Furthermore, high levels of decoding proficiency are needed to engage successfully with a text, and children typically get frustrated when accuracy at decoding drops below 90% (Ehri and Snowling, 2004) because they are unable to decode quickly enough. In their longitudinal study of spelling and reading, Caravolas, Snowling and Hulme (2001) reported that one of the best predictors of reading ability was reading itself, in other words that children's reading improved by reading more. However, children will only be encouraged to read if they enjoy, and feel that they are successful at, the reading process (Smith et al, 2012).

### **1.2.1: Spelling and Handwriting**

There are many cognitive and physical processes that contribute towards the ability to write, and impairments in some or many of these processes can affect the quality of the handwriting produced by the children, see Appendix 1: (Difficulties with motor control and

handwriting in children with CP). This section outlines some of these processes which are necessary for the completion of accomplished handwritten tasks.

Once children have learned to write individual letters they start to group letters into chunks (Kandel, Herault, Grosjacques, Lambert and Fayol, 2009), often into units each containing a syllable. At first these syllabic chunks are processed on the basis of phonology, in that articulated speech will generate the spelling of parts of words (Caravolas et al, 2001). As children become more practised at spelling common letter patterns, and handwriting becomes more automatized, then the production of writing can become more sophisticated in that parallel processing may occur (Van Galen, cited by Kandel et al, 2009). The process of spelling a bi-syllabic word is described below in Figure 1.2.

Research into the writing of older children, around the age of eight or nine years, has suggested that rather than use phonological representations to segment words, children start to use graphotactic processing whereby they utilise orthographic rules in their writing. Kandel et al (2009) describe the differences between these types of processing with the example of the word vase in the French language.

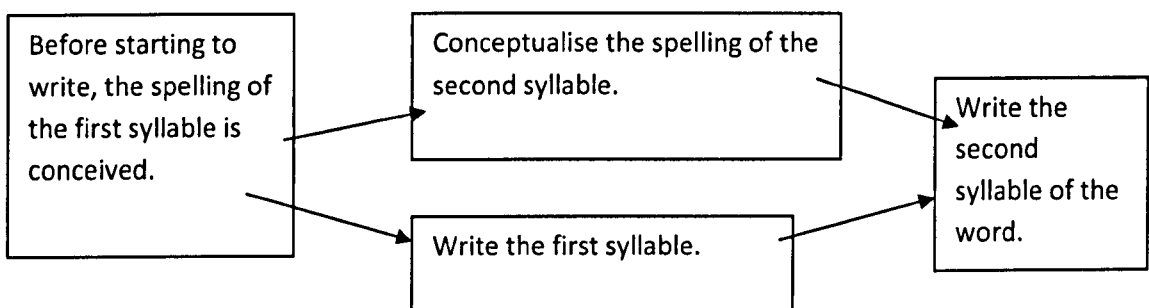


Figure 1.2: The simultaneous processing of the spelling of a bi-syllabic word.

Using phonological rules the word would be written as 'vaz', but using orthographic principles vase is segmented into two units – 'va' and 'se'. Kandel et al suggest this could

be because of the way that French is spoken, particularly when there is an e at the end of a word, however the same principle may be applied to irregular English words. Another example may be the use of a split digraph, such as 'e' at the end of the word changing the sound of the vowel, e.g. pan to pane. The results of Kandel et al's study shows that the level of the complexity of the spellings affected the length of time taken to construct the word and influenced the fluency of the writing strokes, which meant it took longer to write each word. Kandel et al concluded that:

*"...movement duration and dysfluency implicate a supplementary cognitive load"*

(Pg 443)

when children are writing words where the phonological and orthographic syllable boundaries are different.

In the next section, research findings concerning cerebral palsy and how it affects children both physically and academically are examined. There is an explanation of the types of cerebral palsy, and an outline of the research which indicates the way the disabilities associated with CP might affect the development of academic skills.

### **1.3: Children with Cerebral Palsy**

Cerebral palsy (CP) is:

*"a persistent but not unchanging disorder of movement and posture due to dysfunction of the brain, excepting that caused by progressive disease, present before its growth and development are completed. Many other clinical signs may be present."* (World Commission for Cerebral Palsy cited by Griffiths and Clegg, 1988, Pg 11).

The term encompasses a collection of conditions characterised by motor control impairments, paralysis, muscle and posture disorders which are typically diagnosed at birth

or within two years of birth. The number of children affected by cerebral palsy is estimated to be 2.0 to 2.5 per thousand births, and in the majority of the cases the condition is present before birth (Marcovitch, 2005). It is usually caused by some form of brain trauma either during development in the uterus, at the time of the birth, or due to another cause during early infancy (see Appendix 2: Possible causes of cerebral palsy).

The types of CP are identified by the differences between the movement patterns of children with CP and typically developing children. Spastic CP is the commonest type (about 75%) with spasticity of the muscles, which consequently do not contract or relax in conjunction with each other. In typical movements there are pairs of muscles that react together but in opposite ways, some muscles relax while other contract, such as when the arm is moved the triceps are relaxed and the biceps contracted and vice versa. In spastic CP many of the muscles are tense or contracted and have difficulty with relaxing, causing movement to be limited and stiff. Some of the muscles are stronger than others causing atypical posture in limbs or different parts of the body.

Spastic CP may affect the whole body (quadriplegia) or only one side of the body – hemiplegia; or both legs – diplegia. Although one area of the body may be primarily affected such as the legs in diplegia, there may still be some lack of coordination or stiffness in other areas of the body such as hands, arms and in the movements of the eyes (Griffiths and Clegg, 1988). There may also be a lack of coordination between areas such as hand-eye activities which can cause difficulties in fine motor control, reading and writing.

Another type of cerebral palsy is athetoid CP which is caused by damage to the basal ganglia. It is characterised by involuntary movements throughout the body and disturbances in posture. Many children with athetoid CP have normal or high intelligence

but it may be difficult to understand their communication due to facial grimacing and problems with speech production which tends to be spasmodic and abrupt. The last main type of CP is ataxic CP, which is the least common, occurring in less than 10% of children with CP. There is floppiness of the limbs and tremor of the hands together with some difficulties with walking. Again speech may be affected and can be irregular and intermittent.

Generally, CP is caused by lesions in certain areas of the brain, and the size and location of lesions will result in different types of the condition, e.g:

*“corticospinal damage with spasticity, basal ganglia damage with dyskinesia (athetosis) and cerebellum damage with ataxia”* (Pg 528, Kolb and Whishaw 1980).

Kolb and Whishaw also write that it is difficult to locate specific sites of damage as the systems of the brain are linked together. However, nowadays, magnetic resonance imaging (MRI) scans are more accurate at pin-pointing areas of damage but it may still be difficult to quantify or predict the effect of each lesion (Husain, 2002). Children with the more severe forms of CP tend to have more complex learning difficulties due to greater cerebral trauma. However, in general, children with hemiplegia, diplegia and athetosis are often of typical intelligence (Straub and Obrzut, 2009)

There are many other impairments associated with CP such as difficulties with vision, hearing loss, epilepsy, reduced breath control (dysarthria), and hydrocephalus. Many children with CP have hydrocephalus where there may be a blockage to the drainage of cerebrospinal fluid, however it can be controlled by the use of a valve and tube shunt into a ventricle, passing through the jugular vein and into the cardiac atrium (Kolb and Whishaw, 1980). Although the hydrocephalus can be controlled physically, it is claimed that it can still cause:

*“distractibility...(which) may particularly account for at least some of the cognitive and language problems that this patient group exhibits” (Pg 129, Harrison and Owen 2002).*

An additional factor in this complex condition is that many children with CP are born prematurely with extremely low birth weight (ELBW). Whilst this does not necessarily affect the child’s intelligence, Grunau, Whitfield and Davis (2002) state that:

*“despite seemingly adequate cognition, these children frequently experience difficulties in academic achievement” (Pg 615).*

Children with ELBW tend to achieve more poorly than their peers in maths, reading and spelling. In Grunau et al’s study, children with ELBW, in comparison to children of normal birth weight, had learning difficulties within ‘multiple academic domains’ despite having average intelligence rated as 99.3 (full scale IQ) and verbal IQ as 101.2. Their conclusion was that:

*“visuospatial and visual-motor functioning are particularly vulnerable areas in children with ELBW and interact with verbal abilities to affect all aspects of the school curriculum” (Pg 619).*

This raises an interesting possibility that children with CP may have particular learning difficulties due to extremely low birth weight, rather than simply having CP.

### **1.3.1: Evidence of uneven profiles of abilities in children with CP**

Lord (1934), one of the earliest researchers in the field of cerebral palsy, produced case studies of children with CP which showed discrepancies between their speaking abilities and their academic performance. She writes about one boy who at the time was in a hospital school:

*"To the casual visitor who might hear him use correctly such words as 'encephalogram', 'special diet', 'on precautions', it would hardly seem possible that he could not be taught to count reliably above five ....and having traced his three-letter name many times daily that he could not reproduce it below the model"* (Pg 225).

Lord's report is supported by later work into visual and spatial perception which indicated that children with CP have difficulties with copying (Abercrombie, 1964). In the three case studies in Lord's report the children were given Stanford-Binet intelligence tests, and had IQs in the 80s, they were verbally eloquent, but none could read, write their name reliably or complete simple arithmetic. Lord sums up this contrast by saying that the relatively high IQ scores, and the children's verbal ability gives:

*"a false impression of mental capacity... on a child who is not educable"* (Pg 226).

Her studies indicated that the children's teachers were very positive in their beliefs that the children would be taught to read and write but Lord reported that the results of their endeavours were disappointing.

Dorman (1985) completed a battery of tests on an 18 year old young woman with CP, who had the difficulties similar to those described by Lord, to try to find out the reasons for her poor reading and spelling abilities. Dorman suggested that the teenager's reading difficulties were similar to those of people with dyslexia. Despite her low average scoring (verbal IQ 88 on Wechsler Adult Intelligence Scale), her abilities with receptive language and expressive language were not impaired and she also scored typically on the Boston Diagnostic Aphasia Examination tests. However, she had significant problems with phonological processing and manipulation; reading multi-syllabic non-words; and had great difficulties with tests of visual and auditory perception. Thus, Lord and Dorman both studied children and young people with CP with apparently intact vocal abilities and adequate verbal comprehension, but who have difficulties with reading and writing.

Dorman (1985) specifically mentions dyslexia-type difficulties in his study reporting problems with phonological processing and manipulation. These reports correspond to my informal observations of children with CP in the classroom.

The next three sections concern difficulties in the literacy development in children with CP and children with dyslexia. Through the examination of the literature concerning children with CP and children with typical development, it was possible to identify areas of research to be undertaken in this thesis which are: a consideration of phonological processing difficulties, visual/ spatial perception difficulties and problems with working memory, and these are discussed below.

#### **1.4: Phonological Processing Difficulties**

It is generally accepted that phonological abilities are related to the development of reading (Frith, 1985; Caravolas et al, 2001; Ehri, 2002, 2005; Hulme and Snowling, 2009). This section of the literature review will look at aspects of phonological, orthographic and morphological skills which are considered to be necessary for children to learn to read and spell. In addition, there will be a short review of studies in which phonological developmental difficulties have been identified as a precursor or as a cause of children's literacy difficulties, both in typically developing children and in children with CP.

Earlier in this chapter, there was a consideration of the phases in the development of reading and spelling (Frith, 1985; Ehri, 2002). After the initial phase of implicit word recognition, children learn the alphabet by the names of the letters or by their sounds. This initial phase of letter/ sound correspondence, the pre-alphabetic phase (Ehri, 2005), is crucial as children who are unable to master this relationship (Snowling, 1987) will be unable to progress to the stage of developing phoneme/ grapheme representations in the



alphabetic (Frith, 1985) or the full alphabetic phase (Ehri, 2005). There are several reasons why children are unable to develop letter/ sound or grapheme/ phoneme correspondence (Snowling, 1987) including difficulties with phonological awareness, phonemic segmentation, phonological output or problems with auditory memory (Hulme and Snowling, 2009).

Some children learn to read by mostly using orthographic or word identification skills (Apel, 2009; Vellutino and Fletcher, 2005) but studies have shown there is a relationship between the development of alphabetic and phonological processes and the development of word recognition and spelling (Caravolas et al, 2001). Letter/ sound and grapheme/ phoneme skills are necessary in the acquisition of orthographic and morphological knowledge (Vellutino and Fletcher, 2005; Caravolas et al; 2001; Bryant, Nunes and Bindman, 1997). The English language has many irregularly-spelt words and children need to learn how to segment words in syllables or orthographic clusters to learn how to spell (Caravolas et al, 2001) or to break down segments of words when learning to read.

One of the most common problems affecting children with dyslexia concerns deficits in phonological awareness and processing (Vellutino and Fletcher, 2005; Snowling, 1987; Frith, 2002; Hatcher and Snowling, 2002; Snowling, 2008). In these studies, children with dyslexia had difficulties with: grapheme/ phoneme identification, segmenting words, rhyming tasks, sounding out (decoding) words, and word identification (Snowling, 1987; Hatcher and Snowling, 2002).

There have been a number of studies on the phonological abilities of children with CP (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Bishop, 1985; Bishop and Robson, 1989; Bishop, Byers Brown and Robson, 1990; Card and Dodd, 2006; Peeters,

Verhoeven, van Balkom and de Moor, 2008; Vandervelden and Siegel, 1999, 2001; Hart, Scherz, Apel and Hodson, 2007). However, all of these studies have focused on children with communication difficulties or speech and language problems. The only studies of children of young people with CP who have typical oral language abilities have focused on general literacy abilities, (Dorman, 1985, 1987) with phonological awareness or processing as part of a battery of tests.

Generally, the results from studies on children with CP and communication difficulties showed that their phonological processing abilities were related to their reading skills (Vandervelden and Siegel, 2001; Dahlgren Sandberg and Hjelmquist, 1997). Other studies of children with CP and communication difficulties, and children with CP who were AAC users, found that children who had some skills in letter/ sound correspondence were unable to use those skills in building-up spellings (Vandervelden and Siegel, 1999; Dahlgren Sandberg, 2001). Additionally, comparative studies of children who had CP, either speakers or non-speakers, (Card and Dodd, 2006; Bishop, 1985; Bishop et al, 1990) found that the non-speakers had poorer phonological processing abilities than the children who could speak. In all of the above studies, the children with CP had poorer phonological processing abilities than typical children matched by ability.

Studies of children or young people with CP, who can speak, have shown that phonological awareness is not highly correlated with reading test scores (Dorman, Hurley and Laatsch, 1984; Dorman, 1987) but were significantly correlated with non-verbal auditory tests involving pitch and rhythm from the Luria-Nebraska Neuropsychological Battery, (Golden, Hammeke and Purische, 1978) and verbal intelligence. Generally, levels of ability in the children, on all literacy measures: reading recognition from the Wide Range Achievement Test (Jastak and Jastak, 1978); and reading comprehension from the Peabody Individual

Achievement Test (Dunn and Markwardt, 1970), were lower than might be expected in comparison to their verbal intelligence, especially tests for receptive language (Dorman et al, 1984).

In conclusion, the body of evidence indicates that children with dyslexia often have problems with phonological processing which affect their literacy development (Vellutino and Fletcher, 2005; Snowling, 1987; Frith, 2002; Hatcher and Snowling, 2002; Snowling, 2008). Children with CP and communication difficulties appear to have difficulties with some phonological processing skills, although the number of studies has been few and results have been inconsistent (Card and Dodd, 2006; Bishop, 1985; Bishop et al, 1990; 2001; Vandervelden and Siegel, 1999; Vandervelden, 2001; Dahlgren Sandberg and Hjelmquist, 1997). This suggests that the phonological abilities of children with CP, who have typical verbal abilities, should be examined to see if their phonological processing abilities are comparable with their literacy skills and their learning abilities, particularly as this would provide a useful replication of Dorman's findings. Comparisons of this new data with studies by Dorman (1985; 1987) may give a clearer picture of the phonological abilities of children with CP who can speak. Lack of relevant studies have made it unclear whether all children with CP may have phonological impairment or whether this just relates to the samples of children with communication difficulties. A further examination of the literature and a study concerning children with CP and their phonological abilities is described in Chapter 4.

In addition to phonological issues, the vision of children with CP can be impaired in numerous ways and this may affect their ability to develop literacy skills. In the next section there is therefore a review of the literature regarding visual processing, visual perception and reading.

## **1.5: Visual and Spatial Perception and Processing**

A substantial amount of research has been carried out into the relationship between visual processing and literacy. It is a very complex area of research as there are many disorders involving visual processing and perception that are generally claimed to impede the development of reading, spelling and writing (Stein and Walsh, 1997), and which have been extensively researched as causal features in dyslexia (Everatt, 2002).

This part of the literature review examines research into visual processing systems. These can be divided into two distinct areas of visual functioning: the visual motor systems which involve the muscles in and around the eye; and the sensory system which involves the processing and analysis of information which is transferred from the eyes into the brain (Evans, 2001). This is followed by a review of early research which suggests that children with CP have impaired visual perception.

### **1.5.1: Visual motor systems**

There are findings from a relatively small number of investigations that indicate that children with CP are at risk of a range of disturbances to the visual system. These can affect the fixation, convergence and focusing of the eyes which is likely to impair the ability to scan across text (Schuett, Heywood, Kentridge and Zihl, 2008). Schuett et al described how eye movements can affect the process of reading from left to right on a page (see Figure 1.3) particularly as the area of focus (outlined in red) is small on a printed page. The eyes are only able to focus on small amounts of text at one time, and it is important that eyes can:

*“...move in such a way as to allow for the extraction of spatially distributed visual information which is in harmony with the speed of comprehension” (Pg 2446)*

whereby saccadic eye movements and periods of fixation interchange to allow word recognition and comprehension (see Figure 1.4).

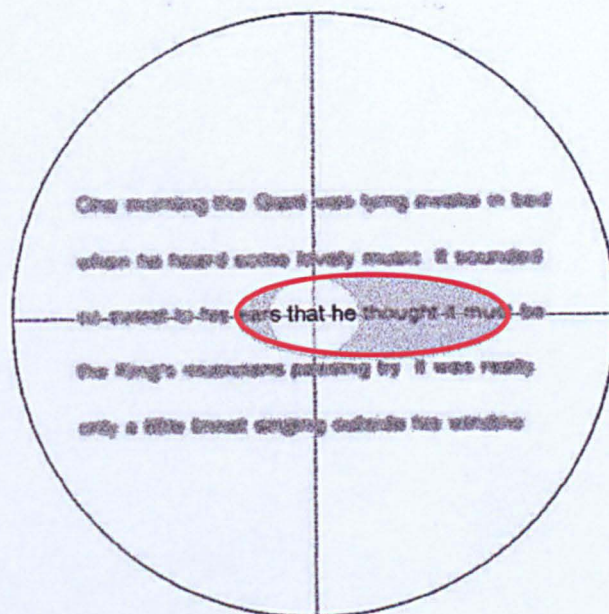


Figure 1.3: Diagram showing visual field and perceptual scan of typical readers (Schuett et al, 2008)

A study of 105 children with CP was completed to discover whether the children had impaired visual processing which might affect the children's reading abilities, (Kozeis, Anogeianaki, Mitova and Anogianakis, 2006). The children were given the Developmental Eye Movement test (DEM, Richman and Garzia, 1987). Only 19% of the children had normally-functioning eyes; 20% had oculomotor difficulties; 32% had a visual perception problem; and 27% had combined oculomotor and visual perception difficulties. Unfortunately, no detailed information was provided about the visual perception tests and the individual results of each perception test were not given. These figures might reveal which tests the children found most difficult and if the tests were related to specific types of CP.

Another difficulty with visual processing occurs in children with CP due to inability to focus due to lack of convergence. Jackson, Castleberry, Galli and Arnoldi, (2006) studied 131 children with CP at their clinic to check for visual processing difficulties. They found that 45% of their patients had vergence problems whereby each eye may have normal vision, but the two eyes do not simultaneously move in order to focus. Sometimes the problems concern intermittent convergence where the eyes have spasmodic or sporadic focusing episodes (see Figure 1.4).

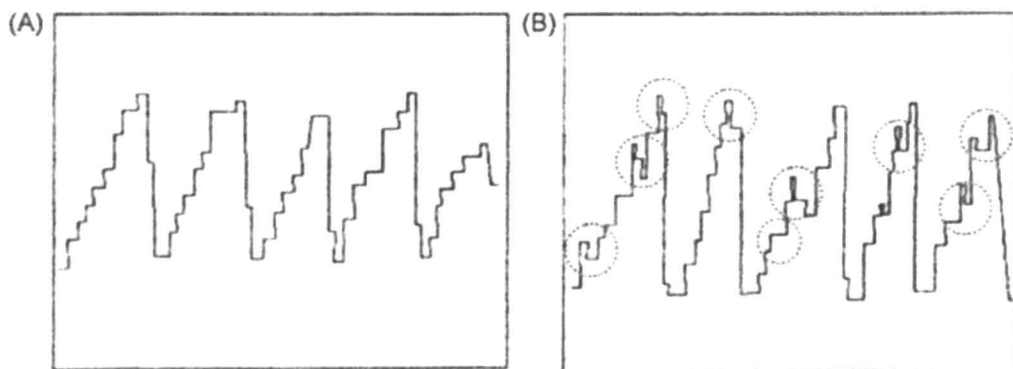


Figure 1.4: Eye movement patterns in a child with CP (Schuett et al, 2008, Pg 2452)

Diagram A (in Figure 1.4) shows the difference in the eye movements of the left eye in comparison with those of the right eye (Diagram B) occurring simultaneously in a child with hemiplegic CP. Problems with focusing patterns often occur in CP, particularly in children with hemiplegia, (Schuett et al, 2008) slowing down reading fluency and increasing errors in word recognition. Jackson et al say:

*“What is not clear is whether poor vergence is the cause of strabismus (squinting), the result of strabismus, or simply related through a common underlying cause”*  
(Pg 93).

Eye movements are often ignored in eye examinations and poor visual processing can cause many problems in normal life such as with reading and writing as well as daily living skills (Schuett et al, 2008). Normally strabismus can be corrected, or partially corrected with an operation, but in the case of children with CP there is often variability in the angle of the squint, and there is an increased risk that an operation might cause an overcorrection. Thus, few children with CP have eye operations, although a number may have corrective devices such as glasses or eye patches to improve focusing, and training (therapy) can be given (Schuett et al, 2008).

### **1.5.2: Visual processing and literacy development in CP**

Early research into visual perception and its connection with literacy was often based on comparisons of children with neurological impairments and typical children. Many of the children with neurological impairments had cerebral palsy (Werner and Strauss, 1941; Dolphin and Cruickshank, 1951; Frostig, Lefever and Whittlesey, 1961). One of the areas of research concerned the testing of children with CP for difficulties with visual processing. Some researchers were unsure whether the children's visual processing difficulties were caused by their vision or because of the children's motor difficulties. Abercrombie (1964) was one of the first researchers to analyse copying tasks to assess where any difficulties lay. An example is shown in Figure 1.5 of a task where shapes, on the left in each grid, are copied and shown on the right.

In each case the child with CP (aged 15 years, 3 months) was able to perceive elements of each shape which she has copied, e.g. the corners of parts of the diamond in the top left grid. However, she was unable to pull the elements together to make a cohesive whole.

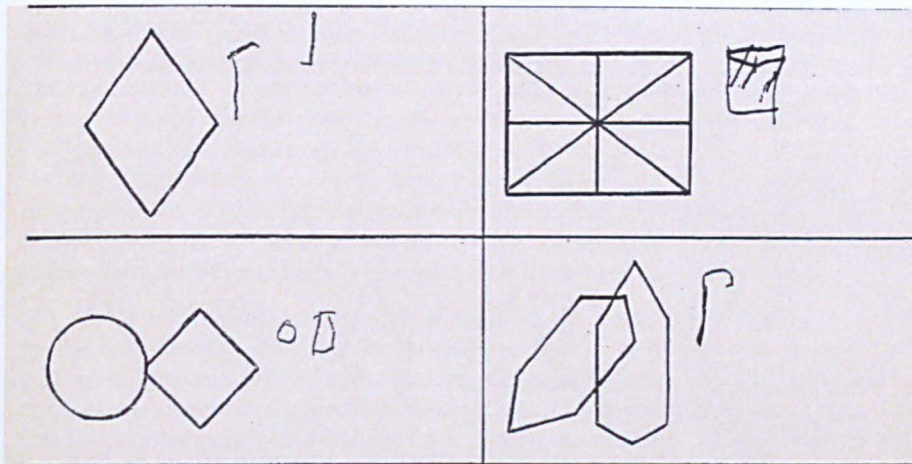


Figure 1.5: Copying simple shapes (Abercrombie, 1964, Pg 2)

Consequently, Abercrombie suggests that the child's difficulties with copying are due to a construction difficulty (copying and placing each shape together) rather than an inability to perceive the individual shapes in each grid.

Support for this viewpoint was provided by Koeda, Inoue and Takeshita (1997) who investigated links between visual disturbance, visual perception and motor control in children who were preterm and had CP. They reported that children with CP often had difficulties with copying or producing Chinese writing characters and shapes. Their results showed that the children's problems with copying shapes or completing pictures in their tests were not caused by visual acuity difficulties, strabismus or other visual disturbances but were caused by constructional dyspraxia: an inability to put together the lines or shapes in a particular order or structure. There is evidence to support a relationship between handwriting skills and general perceptual abilities in children with CP, but those concerning visual skills were not correlated with handwriting performance in a study by Stewart, Pratt and McFadyen (1997).



Other researchers looked into the visual perception difficulties of children with CP, in relation to their reading abilities (Dorman, 1987) or language and literacy abilities (Dahlgren Sandberg and Hjelmquist, 1997). In each study children with CP had visual and perceptual processing difficulties but there were no significant correlations with reading. However, results were reported as group mean standardised scores or as percentages and in the latter study the literacy tests were not standardised, but were adapted for the participants with CP. This makes it difficult to analyse or compare results between the studies.

Thus, there is evidence of visual processing impairments in children with CP but some doubts as to how much an influence this may have on literacy development. Medical and psychological researchers have highlighted that many children with CP have impaired visual and spatial systems. Claims have been made that visual processing and perception difficulties will affect the development of literacy skills but there is not strong support that this is the case for children with CP. A further examination of the literature and a study concerning visual and spatial perception and its relationship to the development of literacy skills is described in Chapter 5.

### **1.6: Working Memory Systems**

Baddeley, (2007) describes the working memory system as:

*“... a temporary storage system under attentional control that underpins our capacity for complex thought.” (Pg 1)*

He suggests that there are four components to the model: a central executive that controls attention and three sub-systems with temporary storage: the phonological loop; the visuospatial sketchpad (VSSP); and an episodic buffer which integrates more general

memory storage. The diagram below (Figure 1.6) describes the connections between these elements (Baddeley, 2000)

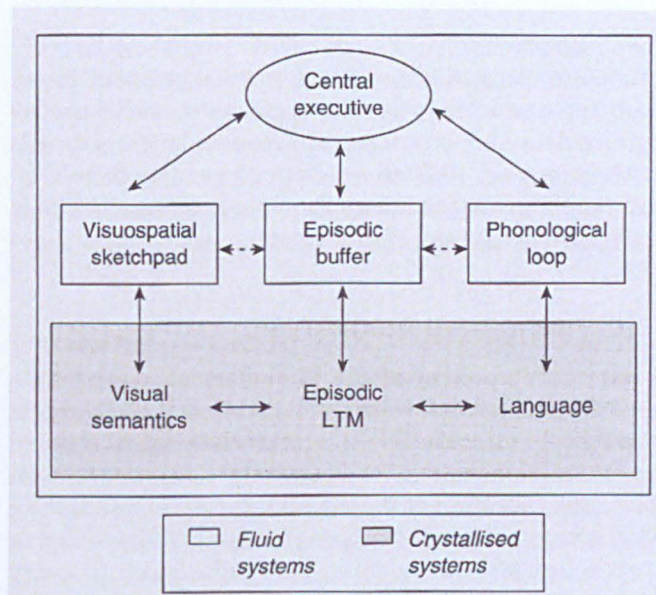


Figure 1.6: Model of working memory by Baddeley, (Henry, 2012)

The phonological loop can hold phonological information, speech-based information and acoustic or auditory information, which can be directly accessed by the phonological store. The visuospatial sketchpad (VSSP) concerns visual information such as images, pictures and numbers. As well as manipulating information between the two main components, the central executive is responsible for attention switching between the components. Visual information from the VSSP is often recoded into a verbal form which enables it to be stored in word form with the use of the articulatory rehearsal mechanism (see Figure 1.7).

The phonological store and the VSSP are considered to hold information as a memory trace for up to two seconds (Baddeley, 2007) so that information needs to be constantly rehearsed to keep it in short term memory. Some tasks require information to be accessed

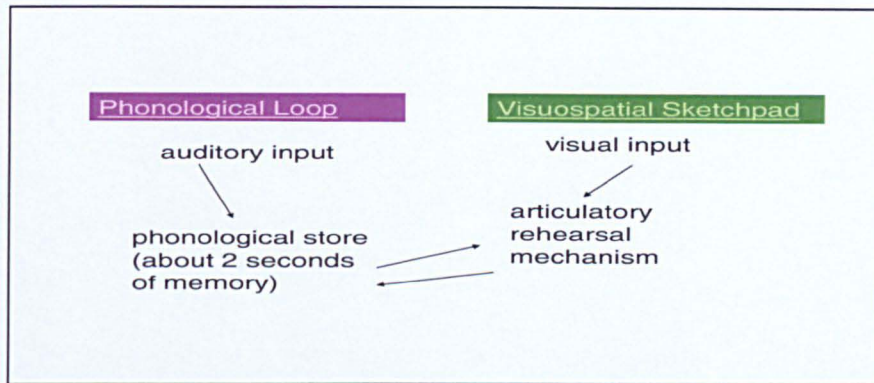


Figure 1.7: Diagram of the articulatory rehearsal mechanism ( Pg 8: Henry, 2012)

from long term memory stores and the interaction between the phonological store, the VSSP, long term memory and the articulatory rehearsal mechanism occurs via the episodic buffer (Baddeley, 2007; Henry, 2012). Two components of memory namely phonological short term memory and working memory have been suggested to be the best predictors of reading ability (Singleton, 2002; Boets, Wouters, van Wieringen, De Smedt and Ghesquiere, 2008), with working memory most utilised for comprehension and word recognition.

The development of the working memory model and its measurement through a series of tasks has been researched in many studies, both with typical populations of children and those with impaired literacy development such as dyslexia (Hulme and Snowling, 2009; Henry, 2012). The next section of this review will describe research into the working memory of children with dyslexia followed by children with CP.

### **1.6.1: Children with dyslexia**

Many researchers believe that the impairments typically found in dyslexia are due to poor phonological representations, while others believe that they are due to poor phonological memory, that is the memory of the phonological representations (Hulme and Snowling, 2009; Gathercole, Briscoe, Thorn and Tiffany, 2008) . Children with dyslexia are often

identified as having problems with verbal short term memory (Hulme and Snowling, 2009), particularly regarding the sound structure or rhyme in spoken words. Consequently, children with dyslexia are more likely to have problems identifying the 'wrong' word within sequences of words in memory tasks. Problems with remembering sequences of words or nonwords in phonological short term memory (PSTM) tests by children in comparison to mental age (MA) and chronological age (CA) matched control groups correlate with children's reading difficulties, and may be related to speech rate or production (Hulme and Snowling, 2009). Children with dyslexia have particular difficulties with nonword recall tests (Hulme and Snowling, 2009; Henry, 2012). Henry (2012) reports that when children with dyslexia are asked to recall visually presented information such as words or pictures, they have similar problems. Hulme and Snowling (2009) say that this is due to 'confrontation naming' where children with dyslexia are slower at naming pictures in comparison to CA-matched controls. They suggest that poor abilities in confrontation naming as well as difficulties with rapid automatized naming (RAN) may reflect a problem with inefficient storage of phonological representations.

An additional issue is that many people with dyslexia also have difficulties with visual spatial perception. Young adults with dyslexia (Smith-Spark and Fisk, 2007) had difficulties with verbal span tasks such as digit, letter and word recall measures, and also had difficulties with VSSM tasks. The participants also had problems with visual spatial scanning tasks (on a computer) including one concerning visual sequential memory. Smith-Spark and Fisk considered that their participants had problems within the central executive system due to impairments in both the phonological and visual systems in comparison to controls.

### **1.6.2: Memory and Literacy in Children with CP**

A number of studies have been completed concerning memory deficits in children with CP, either relating to literacy (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008) or relating to the acquisition of mathematical or arithmetical development (Jenks, de Moor, van Lieshout, Maathuis, Keus and Gorter, 2007; Jenks, van Lieshout and de Moor, 2008) and one to a combined study of reading and arithmetic impairment (Dirks, Spyer, van Lieshout and de Sonnevile, 2008). Bishop et al (1990) also carried out a study to find out if there was a relationship between language comprehension, speech production and phoneme discrimination, involving children with CP who had no speech, and a control group, with matched mental ages, who had speech. All of the studies found that there were impairments to short-term or working memory which affected the performance of the children in Maths or Literacy in comparison to typically developing control groups.

There appears to be a relative lack of studies into the working memory systems of children with CP who are able to communicate verbally, and may have a different profile of attainment from children with CP who are unable to verbalise. Thus, it was decided to assess whether the components of the working memory system were impaired in children with CP, who are able to communicate verbally, and if so whether these impairments were related to the children's literacy abilities. This is addressed in Chapter 6 where there is a study into the working memory of children with CP who have more typical communication abilities.

## **1.7: Overview of the studies: research questions and methods**

### **1.7.1: Aims**

The aim of this thesis was to find out whether children with CP have difficulties or delays in aspects of their literacy development (reading, spelling, writing); and to understand why this may be the case despite the children appearing to have typical abilities in other curriculum areas. The research aimed to answer three questions:

Do children with CP have impaired literacy abilities?

Do children with CP have impairments in areas of cognition which might be expected to affect their literacy difficulties?

Are cognitive abilities related to literacy abilities in children with CP?

In order to address these questions, and informed by the research literature, a number of standardised assessments were utilised to test an opportunistic group of children with CP. The children were assessed using literacy tests and other measures were chosen to aid in the analysis of cognitive difficulties which had been identified in the literature review. The cognitive tests were designed to assess whether the children had: any learning disabilities; phonological processing difficulties; problems with visual or spatial perception; or difficulties within the working memory system which might affect their literacy development. The battery of tests comprised:

1. Assessments of literacy ability: three main areas of tests were utilised – reading, spelling and handwriting (Chapter 2).
2. Assessments of non-verbal and verbal abilities: a non-verbal assessment (Raven's Matrices), a communication assessment, two semantic vocabulary tests and a receptive vocabulary test (Chapter 3).

3. Assessments of phonological processing abilities: a phonemic segmentation task; a verbal fluency (alliteration) test and a rapid naming task (Chapter 4).
4. An assessment of visual and spatial perception and processing abilities (Chapter 5).
5. Assessments for working memory (Chapter 6).

### **1.7.2: Using controls or comparison groups**

A review of studies involving children with CP suggested that the choice of control groups was often problematic. Many studies used children with CP as controls when they did not have a disability which was the focus of the investigation, e.g. verbal abilities (Bishop et al, 1990); or had to find much younger children to match on mental age (Card and Dodd, 2006; Sabbadini, Bonanni, Carlesimo and Caltagirone, 2001) which affected the interpretation of their results. A fuller account of these studies is given in Chapter 3. Controls or comparison groups are often used where the assessment measures are not standardised or where participants use different methods to perform tasks, e.g. if children have to use symbols because they are unable to talk. As standardised tests were used in this study, and the children were able to access them without a need to alter the procedures, the percentile scores from the tests have been used to evaluate whether the children's abilities and difficulties were different from that expected for their age, without the need for comparison groups.

### **1.7.3: Ethical Considerations**

Educational research is guided by principles set down by the British Educational Research Association (BERA, 2011). Researchers are responsible for ensuring that participants are treated 'within an ethic of respect' (BERA, 2011), particularly as the participants in the studies are all children with CP, most of whom are affected in all four limbs. Care and consideration was given to the fact that these children can tire quite quickly, or lose

concentration due to muscle fatigue or spasm. The children were only expected to do short tests at any one sitting, or the tests were broken down into sections. Appropriate informed consent was obtained from the senior management and the governors of the schools, the parents and the children involved. Both the parents and the children had letters seeking for their consent to join in the research to ensure that they understood the process (BERA, 2011) and it was made clear that if a child showed signs of being tired or 'fed up' that each test would be concluded.

The tests were carefully chosen to match the age of the children, and the design and the length of time to complete each test was given consideration. Because the tests could have been difficult for the children to complete, it was necessary to look for signs of discomfort or distress and to discontinue the testing at that point. BERA guidelines suggest that the dual role of a teacher and researcher may affect the children's participation in the research process. There might be a feeling of constraint that the children had to complete the activities as I was a teacher at the school. Therefore, it was necessary to emphasise to each child that the assessments were not part of school work and that they could end them when they wanted.

#### **1.7.4: The studies**

Many researchers report their findings as group means, and this can affect interpretations of the results, for example mean scores alone will not show how test results are distributed within a population (Snowling, 2008). Descriptive statistics: means and standard deviations are included in the tables of results in order to make comparisons with previous findings. However, it was decided to report the results of all the children individually because that would provide insight into their performance within each set of assessments, and also in comparison with each other.



There are five separate studies with the same fifteen participants, each devoted to a particular area of cognition: literacy skills; learning abilities, phonological processing, visual and spatial perception, and working memory. Each study is reported in an individual chapter. As the participants are the same in each study, each chapter consists of an introduction with a short literature review, a section devoted to an explanation of the tests that were used, followed by the results and a discussion. The last chapter of the thesis is a discussion of all the studies, the limitations of the research, and ideas for future research.

## **Chapter 2: The children's literacy abilities**

### **2.1: Introduction**

The first chapter established that few researchers have provided a comprehensive examination of literacy development in children with CP. In contrast, there have been a relatively large number of researchers who have investigated specific aspects of literacy difficulties in children with CP, such as the way phonological abilities were related to the reading of children who have poor communication or little speech (Bishop et al, 1990; Vandevelden and Siegel, 1999, Dahlgren Sandberg and Hjelmquist, 1997: Dahlgren Sandberg, 2001) while others have looked at handwriting difficulties, (Stewart et al, 1997; Bumin and Tukul Kavak, 2008); spelling (Bishop, 1985), and short-term memory (Bishop and Robson, 1989). There is a consensus that, despite having similar general learning abilities to control groups, children with CP and communication difficulties, also have poorer phonological, reading, spelling and handwriting abilities.

There is very little research on the literacy abilities of children with CP who appear to have typical speech abilities other than the work of Dorman (1985; 1987; Dorman et al, 1984). His studies on teenagers with CP utilised a battery of standardised tests, and his findings indicated that many of the teenagers had problems with literacy but their general learning abilities were at typical levels. Consequently, in this thesis, it was decided to assess the literacy skills of an opportunistic sample of children with CP to identify the extent of their difficulties and whether these involved decoding, spelling and writing. A range of standardised assessments were selected (as outlined in Chapter 1) and these are described below with a consideration of their use in studies of children with CP.

The development of mental orthographic representations (MORS, Apel, 2009) or a sight-vocabulary is considered to be essential for fluent reading and is relevant to everyday activities. One of the most common types of reading test involves the decoding of single words (Vellutino et al, 2004). Such assessments can be timed as some researchers propose that children with reading difficulties will take longer to recognise or parse lists of words (Frith, 2002; Fawcett and Nicolson, 2004). Dorman's (1985) 'KS' case study of an 18 year-old young woman with CP involved a battery of tests from the Luria-Nebraska Neuropsychological Battery, (Golden, Hammeke and Purische, 1978), namely tests for motor performance; oral motor movements; fine motor performance; trail-making; visual and spatial processing; verbal and visual memory; and the rhythm subtest. The test results suggested that KS had impairments in visual spatial processing and visual scanning; poor visual memory and poor rapid non-verbal acoustic stimuli; and that these difficulties might impede the development of literacy skills. Dorman also wanted to find out why she had poor literacy skills in comparison to her verbal IQ (88) using Weschler Adult Intelligence Scales (Wechsler, 1981), including two word recognition, or decoding, tests.

Dorman found that KS was able to read most short, phonetically regular words accurately but had problems with multi-syllabic words. Using her verbal ability scores as a comparison, KS had low scores on the Peabody reading recognition test and the Woodcock word identification task. These were untimed tests and she was able to use phonological knowledge to build up letter sounds into words, without time penalties. Dorman reported that most of her errors were due to an impairment in the visual analysis of letters in each word, or problems with syllable identification suggesting that she was still working towards the full alphabetic phase (Ehri, 2002), alphabetic (Frith, 1985) or stage 3 of Marsh et al's (1981) model.

Many children with dyslexia have also been identified as having phonological processing difficulties (Frith, 2002; Vellutino et al, 2004; Snowling, 2008), through assessments involving sentences or passages containing nonsense words or non-words. These assessments provide information about a child's ability to be able to read novel words by processing graphemes into phonemes when they are provided with contextual information that could aid the children. Other assessments contain a list of words which are phonologically plausible but are not real words. This type of test purely assesses decoding abilities as semantic cues would not be available and children would have to use alternative strategies. Both types of non-word assessments were used in this study (see section on Methods for a description of the tests).

An example of the latter nonword assessment involved KS (Dorman, 1985) who was given a list of fifty nonsense words, of which she was able to read twenty-six correctly. The majority of her errors consisted of vowel additions where KS pronounced the vowel with its name rather than using the relevant phoneme. Dorman says that very young children can make this kind of mistake because they are unsure of phoneme/ grapheme associations. While KS was able to use her skills to read real words, she reverted to a previous phase of development and an earlier representation (Critten, Pine and Steffler, 2007) when she was unable to use conventional strategies to decode nonsense words. When she read longer words, KS was able to sound out each letter but was unable to join them correctly. Dorman suggested that she had difficulties with her auditory memory because she was unable to remember each letter, or the sequence of those letters, when pronouncing nonsense words.

Another type of reading test such as the Salford Sentence Reading Test, involving sentences, (Vincent and Crumpler, 2002) is used in many schools. At the beginning of the

assessment the sentences are simple with short cvc words, and large fonts, but gain in complexity as the test progresses. These tests allow the child to make a number of errors before the test is stopped, and the last error is used to calculate a reading age. This kind of test allows the child to use both verbal and visual coding processes (Vellutino et al, 2004) and sight vocabulary but also assists the child that has good language or semantic skills as context and syntactic strategies may be utilised.

As well as decoding, there has been research into reading comprehension involving children with CP. Dorman's study (1987), on reading achievement and visual and verbal perception, involved assessments of thirty-one adolescents with CP using word recognition and reading comprehension tests. The results showed that the young people had poorer scores on the comprehension tests in comparison with their verbal IQs while they were only mildly impaired on the recognition test (mean scores: Verbal IQ: 88; Reading recognition: 82; Reading comprehension: 67). Dorman concluded that the low comprehension scores were due to poor word recognition in the comprehension test, rather than poor comprehension skills per se. The studies by Dorman (1985; 1987) and Dorman et al (1984) suggest that the children and young people with CP, with typical verbal abilities, often have literacy abilities below the level that might be expected based on other tests. It was decided not to use a reading comprehension test in this study mainly because comprehension tests involve long passages of text which may have taken the children a long time to decode, causing children with CP to become fatigued and affecting their performance.

The section above outlines how the difficulties or delay with literacy development affected the young people considered to have abilities in the typical range. However, these are the only studies which specifically look at reading skills where verbal communication is present

in the participants. This lack of research makes it problematic to compare the findings from this present study to other studies in the literature, but it might be anticipated that some of the children in this study will have difficulties and abilities similar to those of KS (Dorman, 1985). Thus, this study will help to fill a notable gap in research involving children with CP.

Spelling is a significant component of literacy abilities. KS (Dorman, 1985) was given a spelling test and made a number of errors. An error analysis revealed that the majority were non-phonetic, showing that she was mainly using visual memory to spell. The words in the spelling test were phonetically regular, so the fact that KS was making visual errors suggested that she either did not hear the words correctly or did not remember them correctly when she wrote them. Dahlgren Sandberg (2001), in a longitudinal study, tested six non-verbal children with CP at the ages of six, nine and twelve, on spelling, with six typically developing children matched by gender and non-verbal IQ (Ravens progressive coloured matrices). All the children made progress with their spelling over the course of the study, but the children with CP lagged in their development relative to the controls. Dahlgren Sandburg suggested that the children with CP lacked secure representations of language and its associated phonemes and graphemes. The study in this thesis contains a spelling test which is timed over two minutes. It contains a number of single syllable words at the start, followed by increasingly difficult words.

Handwriting follows a similar developmental pattern to reading and spelling in that there are a number of prerequisite skills that need to be developed in order that children can learn to write (Feder and Majnemer, 2007). Studies reported by Berninger (2009) suggested that three cognitive components are necessary for acquiring writing skills. The first is the ability to hold images of written words in the memory while spelling and writing;

the second is the necessity to hold the oral or spoken word in the memory while interpreting the phonemes; while the third is the ability to analyse and manipulate the letters within words. This may explain some of the difficulties encountered by KS (Dorman,1985), who constantly had difficulties with holding phonemes or syllables in her memory while reading, spelling and writing.

One general limitation of most previous studies on children with CP is that, in common with many studies of children's literacy abilities, the researchers have reported group means (Asbell, Donders, Van Tubbergen and Warschausky, 2010); or chronological and mental ages (Vandervelden and Siegel, 1999). This makes it difficult to assess the extent of reading difficulties of children in a sample, for example, whether all or just some of the children have such difficulties, and it doesn't tell us about the range in individual performance. These are important issues as in one or two investigations; comments were made by researchers that some children had scored well in certain tests (Bishop et al, 1990; Dorman, 1985; 1987) but this is not obvious from the mean performance of the group. As a result, the findings from the assessments in this thesis will be reported for each child.

Another concern is that, in comparison to literacy development in typical children (Caravolas et al, 2001) or children with literacy or language difficulties (Hulme and Snowling, 2009), only two longitudinal studies have investigated the literacy abilities of children with CP over a number of years. A battery of spelling, reading and phonological tasks were given to seven children with severe speech impediments who were aged 5-7 years at the start of the study (Dahlgren Sandberg, 2001). There were two time points with a gap of 3-4 years between testing. The other longitudinal study spanned over 18 months with three time points, concerning 52 children with CP, with an average age of 5.8 years at the first time point (Peeters, Verhoeven, de Moor and Van Balkom, 2009b). In both studies

the children were assessed as having mild intellectual abilities to typical intelligence or above, and were matched with mental-age comparison groups of typically-developing children.

In both studies the children were given a list of words to decode, which they had to match with pictures, however there were discrepancies over the time points. In the Swedish study, Dahlgren Sandberg added two new reading tests at Time point 2 to avoid ceiling effects, while in the Dutch study; Peeters et al only added the decoding test at Time point 3. The results from both of the studies indicated that children with communication disorders are more likely to have delayed development in literacy skills in comparison to mental-aged matched controls, and in the Dutch study, also in comparison to children with CP who had better communication skills. No longitudinal studies have been completed on children with CP who all have typical communication abilities. In order to address this lack, there is a longitudinal study involving a subset of the sample (the first six children who were tested), who were given two of the reading tests over three time points, which were each a year apart.

Thus, the gaps in our understanding of the literacy abilities of children with CP provided a basis for this investigation. The focus of this chapter is on the literacy abilities of a group of children with CP, and is designed to answer two questions.

### Questions

Do children with CP have difficulties with reading, spelling and writing?

Were there relationships between the different literacy abilities?



## **2.2: Study 1: Literacy abilities of the children**

### **2.2.1: The Participants**

Ten children from one special school and five children from a special school in another county, all with CP, were selected for the study. Due to the diversity of symptoms and conditions under the umbrella diagnosis of CP, children were selected who would be able to complete the assessments and who would be able to communicate their choices and decisions (see table 2.1). The criteria for selection of the participants were as follows:

- The children had to be over the age of six and a half years as they were to be assessed on their reading and writing. This age was selected as children under the age of six would be unlikely to have the skills necessary to complete the tasks (Hulme and Snowling, 2009).
- The children would need to be able to communicate some of their answers verbally in some of the assessments.
- The children would need to have sufficient visual ability to access the tests; this eliminated the need to change the presentation of visual stimuli in the tests.
- The children had to have hearing abilities within typical ranges.
- The children would need to have a learning ability within the average, or low average range, such as to have the ability to learn to read and write in typical circumstances (Hulme and Snowling, 2009).

### **2.2.2: Materials: the assessments**

Overview:

The following tests were employed to assess the children's literacy abilities. Each test was especially chosen for ease of access for the children. The Dyslexia Screening Test-Junior (DST-J) (Fawcett and Nicolson, 2004) is commonly used in schools, and contains a battery of

**Table 2.1: The fifteen children in the study**

Names (changed for confidentiality)	Age at start of testing	Type of CP or description	**Science KS1 assessment	***Science KS2 SAT res/assess	Comments
Ian	6y 9m	Athetoid:all limbs	Level 1-2		Occasional stammer
Will	6y 11m	Spastic hemiplegia	Level 1		
Jon	7y 1m	*Very poor coordination	No information		
Harry	7y 3m	Spastic quadriplegia	Level 1-2		
Linda	7y 10m	Spastic quadriplegia	Level 1-2		Slow speech
Cleo	8y 8m	*Wheelchair user	No information		
Joe	8y 11m	Spastic quadriplegia		Level 4	
Garth	9y 3m	*Athetoid- like CP	No information		Slow speech
Beth	9y 7m	Spastic quadriplegia		Level 4	Slow speech
Lee	9y 8m	Spastic quadriplegia		Level 4	Slow speech
Lewis	9y 9m	*Wheelchair user	No information		
Chris	10y 0m	* Extreme stiffness	No information		Slow speech
Amy	11y 4m	Spastic hemiplegia		Level 4	Slow speech
Emma	11y 5m	Spastic hemiplegia		Level 4	Selective mutism
Rob	11y 6m	Spastic quadriplegia		Level 3	

- \*No medical information available
- \*\* Typical Level at KS1: Level 2
- \*\*\* Typical level at KS2: Level 4

Mean age of group: 9y 2m

assessments which were designed to test for dyslexia or other cognitive difficulties.

Percentile scores were calculated using raw scores, risk factors and percentile cut-off scores. It contains two reading tests which are both timed. Two other, untimed, reading tests were also used: The Salford Reading Test (Vincent and Crumpler, 2002) and the Thames Valley Test Company (TVTC) Graded Nonword Reading Test (Snowling, Stothard

and McLean, 1996). A spelling test and a handwriting (copying) assessment were taken from the DST-J. The children's performance is presented as percentile scores as this takes account of the differences in age and enables comparisons to be made of performance on different assessments.

#### Test 2.1: One Minute Reading Test (Timed decoding): DST-J

The child has a practice of reading six words in a list and then is asked to read from a card made up of four columns each containing thirty words. The scoring is one mark for each word correctly read and, if the naming is completed in less than sixty seconds, additions of one mark for each second less than the sixty seconds. If the child does not know a word they should say "pass" and the test is discontinued after five consecutive mistakes or passes.

#### Test 2.2: Nonsense Passage Reading (Passage containing non-words): DST-J

This is a test in which non-words, which are phonologically plausible, are placed within a passage or sentence which otherwise makes sense. There is a practice passage which includes short sentences including nonsense or non-words. The test is made up of three sections, each of which has been developed to suit the age of the child: 6.5 – 8.5 years (28 words); 8.6 – 10.5 years (36 words) and 10.6 – 11.5 years (42 words). All of the tests contain ten nonsense words, but they have been allocated according to the developmental stage of reading, e.g. the first passage for the younger children contain nonsense words mostly made up of cvc words. An example of part of the passage for the youngest age group is:

*"One day a mib fell into the feg. He was so sup and tid that he cried."* (Pg 25)

The reading is timed to be completed within three minutes, and discontinued at the end of that time or if the child is unable to read five consecutive words. The scoring is one mark for each correct real word and two marks for each non-word with a plausible

pronunciation, or one mark for a close approximation. There is a bonus score if the child takes less time than one minute to finish the test, or a penalty if longer than a minute is taken.

### Test 2.3: Salford Reading Test

This is a non-timed assessment made up of sentences, which are graded and marked in reading ages, and is widely used in schools. There are two equivalent tests (X and Y) which are made up of thirteen sentences each. The X test is designed for children with reading ages up to ten years two months, and the Y test is designed to score up to ten years six months of age. The scores are given as reading ages which can be converted to percentiles with norms of chronological ages between 7.6 years and 12 years. Children are asked to read the sentences and any words that are incorrectly read are marked as errors. After six mistakes the child is asked to stop, and the reading age is scored from the final mistake.

### Test 2.4: TVTC Graded Nonword reading test

This is another untimed test containing a list of phonologically plausible nonwords which have to be decoded. There is a practice section made up of cvc words (consonant-vowel-consonant), followed by groups of words with blends of initial or final groups of letters. The early sections of the test have single syllable words – the first nonword is ‘hast’, followed by two-syllable words of increasingly complexity – the last nonword is ‘sloskon’. Correctly-read words are scored and added together, and reading ages and scores in percentiles can be identified from the provided tables. The children’s chronological ages and their reading ages are shown in Table 2.3.

### Test 2.5: Two Minute Spelling Test: DST-J

This is a two minute spelling assessment, which is divided into two categories according to the age of the child. The first test is for children in the age group 6.5 to 9.4 years which consists of eight single syllable words; while the second one is for children of the age of 9.5 years and over, and consists of twenty-four words of increasing complexity with up to five

syllables. The scoring consists of the number of words which are correctly spelt, but also takes note of timing, handwriting and which hand is used for writing. As some of the children would be penalised in this test due to handwriting difficulties, the children were able to choose whether they wanted to handwrite, type or verbalise their spellings.

#### Test 2.6: Handwriting Test: DST-J

The handwriting test was used to assess the ability of the children to copy a short section of typed text. There are four passages, one for each of the following age groups: 6.6-7.5; 7.6-8.5; 8.6-10.5; 10.6-11.5 years. The score consists of a basic mark for the number of words completed in a minute, and a bonus score if the passage is written below a minute. There are penalty scores for errors, handwriting quality and punctuation errors. Notes were made regarding the number of times children had to reference letter or segments of words.

Examples of two of the handwriting tests are shown in Figures 2.1 and 2.2. They are copies of the best handwriting sample and the worst sample, and shows how the marks are calculated to make up the raw scores. The other children's handwriting samples are shown in Appendix 3 (Handwriting Samples from the DST-J) with the calculations that were used to produce the raw scores.

#### **2.2.3: Data Presentation**

In this and the following chapters of the thesis the data is usually presented in the following sequence: the percentile test scores of all the children are shown in a table together with the means and standard deviations of all the tests; and the number of children in the study who obtained typical (or above) percentile scores (see table 2.2). Percentile scores in the typical range or better (above the 24<sup>th</sup> centiles) are highlighted in coloured cells. This is followed by a table showing the children's chronological and reading ages of two of the

reading tests. Correlations are then calculated between the different assessments to investigate whether the children's literacy abilities are related. The descriptive statistics and correlations were generated on SPSS using Spearman's Rankings with two-tailed significance. In this chapter, additional data is provided about the children's reading abilities across a three year period in a longitudinal study.

### **2.3: Results of Study 1**

Table 2.2 shows the percentile scores of all the literacy tests. The children have been put into ranked order according to their abilities in the first reading test – the one minute reading test from the DST-J.

Table 2.2: Percentile scores from the literacy tests (percentile scores within the typical range are shown in coloured cells)

	I minute reading	Nonsense word pass	Salford Reading	TVTC nonword	Spelling	handwriting
Ian	70	75	58	60	43	1
Lewis	43	73	40	75	26	1
Beth	27	65	26	25	25	10
Garth	16	40	32	1	8	2
Joe	9	21	30	50	9	6
Harry	7	13	7	1	25	5
Emma	3	30	1	4	6	1
Cleo	2	4	6	1	5	4
Linda	2	1	1	1	5	1
Amy	2	5	4	1	5	1
Chris	1	5	5	9	7	1
Rob	1	4	4	15	7	1
Lee	1	2	1	3	5	1
Jon	1	1	5	0	8	3
Will	1	1	1	1	5	1
Means	12.4	22.7	14.7	16.87	12.6	2.6
SD	19.98	27.6	17.89	24.58	11.5	2.6
No of typical scores	3	5	5	4	4	0

Twelve of the fifteen children had percentile scores below twenty-five in the one-minute reading test. Generally, the children had higher percentile scores in the second test, the nonsense word passage test with a mean score of 22.7, but only five of the children achieved typical percentile scores. The ten remaining children had a wide range of percentile scores between the twenty-first and the first centiles, with the lowest scoring eight children in the nonsense passage test also having the lowest scores in the one minute test. A large proportion of the children had very low percentile scores indicating poor decoding abilities for their age.

Looking at the passage or sentence reading tests in Table 2.2, (the Nonsense Passage (DST-J) and the Salford test), overall there was a very similar division of the children into age-appropriate and atypical levels of reading. Generally, there were higher percentile scores for the majority of the readers on the Salford sentence and nonsense passage (DST-J) reading tests in comparison to the tests involving single- word decoding.

On the Salford reading test and TVTC nonwords test the children mainly had percentile scores consistent with the two previous tests. There was a clear defining line between the best readers and the poorest readers in the Salford test, with the ten poorest readers scoring below the seventh centile. Of the five best readers in the Salford test, four gained typical scores in the TVTC test while the other scored very badly. In contrast, two of the poorer readers had higher percentile scores, at nine and fifteen, than the rest of the poor readers group.

Generally, the poorer readers were also the poorest spellers, but one of the poorer readers had a percentile score of twenty-five, while two of the better readers scored below the tenth centile. There was a clear separation between the children with typical scores (at or

above the twenty-fifth centile) and the other children who had scores which were all below the ninth centile. A standard deviation of only 11.5, in comparison to those of the reading tests, illustrated a tighter cluster around the mean and suggested that the children's spelling abilities were not as diverse as their reading abilities.

All of the handwriting scores were at or below the tenth centile, with nine children only scoring in the first centile. A mean score of 2.6 and a standard deviation of only 2.6 demonstrated the children's difficulties with copying simple sentences.

Table 2.3: Children's chronological ages and reading ages

	Chronological Ages	Salford Reading Age	TVTC Reading Age
Ian	6y 10m	6y 9m	7y 10m
Lewis	11y 0m	10y 6m +	11y 5m
Beth	11y 8m	10y 2m +	9y 3m
Garth	10y 6m	9y 7m	<6y 0m
Joe	11y 3m	10y 2m +	10y 10m
Harry	8y 9m	5y 2m	<6y 0m
Emma	13y 0m	7y 8	7y 6m
Cleo	9y 11m	6y 1m	6y 7m
Linda	9y 10m	4y 10m	<6y 0m
Amy	11y 8m	7y 0m	<6y 0m
Chris	11y 3m	6y 11m	7y 6m
Rob	13y 0m	7y 0m	8y 5m
Lee	12y 0m	7y 0m	7y 1m
Jon	9y 4m	5y 1m	<6y om
Will	7y 1m	<4y 3m	<6y 0m

Two of the reading tests provided reading ages (see Table 2.3). As one would expect from the percentile scores, the better readers had age-equivalent scores which were comparable to their chronological age. Also, as one would expect, the poorer readers had age-equivalent scores below that of their chronological age. The age-equivalent scores show the severe difficulties that many of the children with CP had with literacy. In the majority of cases these children had reading ages which indicated that they were performing



similarly to a 6 or 7 year old child when their actual ages were 10 or 11 years. In other words these children could only be considered to be at the beginning of the acquisition of literacy skills.

Between the four reading assessments and the spelling tests, there were eight highly significant correlations above 0.69, and a further two correlations above 0.5, which were significant, (see Table 2.4). This suggests that all five tests were assessing similar abilities despite variations in format (timed; untimed; real and non-words; single reading; passage reading; decoding and spelling).

The TVTC nonwords test had significant correlations with the one-minute test and the Salford test, and a highly significant correlation with the nonsense word passage reading test. All four decoding tests had highly significant correlations with the spelling test, particularly the Salford test with rho of 0.84. The handwriting test had weaker correlations with the other literacy tests, with only a moderate correlation with the Salford reading test. This might be because many of the children had percentile scores of one, and suggests that the children's handwriting scores were not necessarily related to their reading or spelling skills and may be due to motor impairment or for other reasons.

Table 2.4: Correlations between the literacy tests

	1 min reading	Nonword pass	Salford Reading	TVTC nonword	Spelling	handwriting
1 min reading	x	x	x	x	x	x
Nonword passage	<b>.885**</b>	x	x	x	x	x
Salford Reading	<b>.775**</b>	<b>.761**</b>	x	x	x	x
TVTC nonword	<b>.533*</b>	<b>.693**</b>	<b>.563*</b>	x	x	x
Spelling	<b>.716**</b>	<b>.754**</b>	<b>.843**</b>	<b>.755**</b>	x	x
Handwriting	0.313	0.172	0.452	0.05	0.368	x

\*\* Correlation is significant at the 0.01 level (2-tailed).

\*Correlation is significant at the 0.05 level (2-tailed).

The following two handwriting tests are indicative of the difficulties of many of the children. Most of the children were only able to produce a few words because they were slow to copy the provided text within the time limit of a minute. Beth scored more points because she was able to produce clear words with no errors other than lack of spaces, but was penalized because she does not write with a cursive script. Linda was penalized due to her inability to produce clear words.

*"I am copying a short passage. I have one minute to write as much as I can, as well as I can."* (Fawcett and Nicolson, 2004, pg 28)

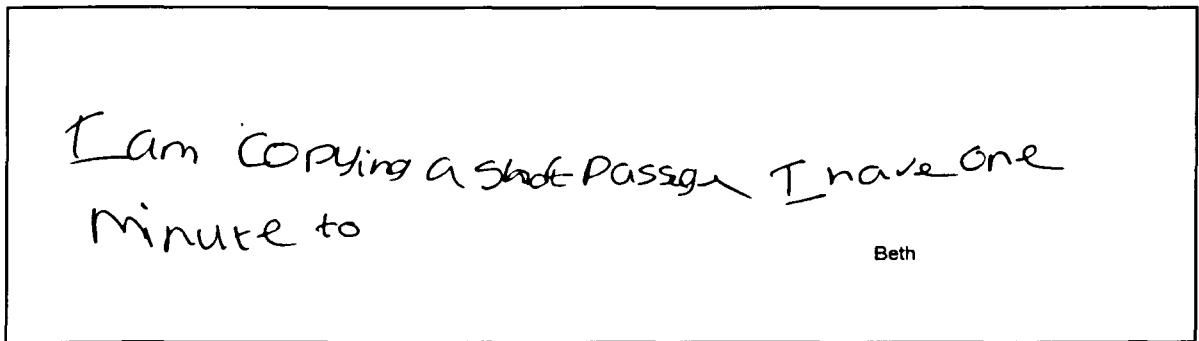


Figure 2.1: Handwriting Test (Beth)

Scoring:  
Words completed: 11  
Errors: 0  
Penalty for writing quality (non-cursive script): -1  
Poor punctuation: -2  
Total raw score: 8  
Percentile: 10

*"I can copy these words in a minute. I am fast as well as neat."* (Fawcett and Nicolson, 2004, pg 28).

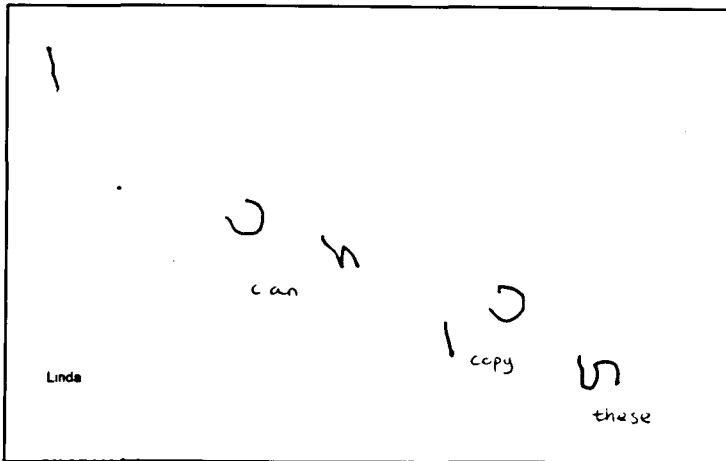


Figure 2.2: Handwriting Test (Linda)

Scoring:  
Words completed: 1  
Errors: -7 (14 errors)  
Penalty for writing quality (illegible): -3  
Poor punctuation: 0  
Total raw score: -9  
Percentile: 1

### **2.3.1: Longitudinal Data**

The following table (Table 2.5) displays the number of words correctly read by each child at each time point on the reading tests (there was a year between each time point). This provides an overview of the children's reading abilities with reference to the performance of children with typical reading percentile scores shown by the coloured cells. The nonsense word passage test provides two forms of data. The first figure is the number of real words correctly read and the second figure refers to the number of nonsense words correctly read. There are forty-two real words and ten nonsense words in the nonsense word passage test.

Table 2.5: Longitudinal Reading Tests: Correctly-Read Words

	One minute reading test			Nonsense word passage test		
	Time point 1	Time point 2	Time point 3	Time point 1	Time point 2	Time point 3
Beth	52	46	57	35 5	42 8	42 10
Joe	15	45	77	34 2	36 10	42 9
Emma	12	11	24	41 5	41 1	41 2
Linda	2	0	6	2 0	14 1	28 5
Rob	4	7	4	28 0	31 0	41 3
Lee	0	11	3	13 0	25 1	37 4

In the one minute reading tests all the children, apart from Rob, achieved an increase in performance in decoding over the three time points which were completed a year apart. The three best readers increased their reading scores more markedly, while the poorer three readers continued to have very low scores. However, in the nonsense word passage test all the children, apart from Emma whose real word score was almost at ceiling level, improved their performance over the three time points. Not only did the children make considerable improvement on the real word scores but even some of the poorer readers were able to correctly read a number of the nonsense words.

Table 2.6: Longitudinal Reading Percentile Scores

	One minute reading test			Nonsense word passage test		
	Time point 1	Time point 2	Time point 3	Time point 1	Time point 2	Time point 3
Beth	27	14	20	65	65	90
Joe	9	23	45	21	25	83
Emma	3	3	7	30	20	7
Linda	2	1	3	1	7	7
Rob	1	1	1	4	8	20
Lee	1	3	1	2	8	8

The percentile scores in Table 2.6 indicate the children's performance and progress relative to the development of typical children. For all the children, except Joe, the variations in the percentile scores for the one minute reading test across the different time points was

less than fifteen centiles which indicates some stability in the scores relative to the progress of typical children, albeit that the percentile scores were mainly low. Joe was the only child to show a marked improvement in his reading skills particularly at Time point 3.

In the case of the nonsense word passage test, where the children’s decoding can be assisted by semantic information, the performance was more varied. Two of the children showed a marked improvement (Joe and Beth) so that by the third time point they were achieving above average scores on the assessment. However, one child showed a decline in percentage scores from 30 to 7 (Emma) which might be because she was older than the test guidance (Emma was 13 years old while the test was designed for children up to the age of 11.5 years), and three children who, despite showing an increase in raw scores throughout the time period, still scored well below typical levels.

Table 2.7: Correlations of the percentile scores of the longitudinal reading tests

	DST-J 1	DST-J 2	DST-J 3	Nonsense 1	Nonsense 2	Nonsense 3
DST reading 1	x	0.746	<b>.941**</b>	0.754	<b>.824*</b>	0.5
DST reading 2	x	x	0.806	0.647	<b>.866*</b>	0.627
DST reading 3	x	x	x	0.638	0.765	0.441
Nonsense passage 1	x	x	x	x	<b>.928**</b>	0.551
Nonsense passage 2	x	x	x	x	x	0.735
Nonsense passage 3	x	x	x	x	x	x

\*\*Correlation is significant at the 0.01 level (2-tailed)

\*Correlation is significant at the 0.05 level (2-tailed)

All the correlations of the literacy percentile scores shown in Table 2.7 were above rho = 0.44 which indicates reasonable consistency across the different time points. Even with this small sample there were a number of significant and highly significant correlations and a number of these were across different time points.

## 2.4: Discussion

The first section of the discussion considers the children's literacy abilities. This is followed by a consideration of the longitudinal data and analyses.

### Do children with CP have difficulties with reading, spelling and writing?

The majority of the children were found to have significant difficulties with reading, spelling and writing. Most of the children had scores below the 25<sup>th</sup> percentile showing that their abilities were in the atypical range. This extends the findings reported by Dorman, (1985, 1987) and Dahlgren Sandberg (2001). However, the picture is variable as some of the children performed at typical levels on the reading and spelling tasks.

The one-minute reading test proved to be the most difficult of the reading tests for twelve out of the fifteen children (Table 2.2), with eleven of the children having scores below the tenth centile. The three remaining children scored within the typical range but only one child (Ian) scored above the 50<sup>th</sup> centile. This test consisted of a list of common words, many of which were one syllable long but, apart from the first few words, most of the words contained digraphs and blends of increasing complexity which the majority of the children found difficult to decode. The other reading test which consisted of decoding a list of items was the TVTC nonword test. Only four of the children achieved typical scores on this test, but some of the older poorer readers (Chris and Rob) achieved their best percentile scores on this reading test (at the 9<sup>th</sup> and 15<sup>th</sup> centiles), which suggests they had sufficient phonological knowledge and skills to decode nonwords, and were able to use these skills to help them read.

Some children had age-equivalent reading ages (see Table 2.3) while others were at the level of beginner readers. There were some anomalies between the age-equivalent scores

of two of the tests: the Salford and the TVTC nonword tests. Generally there is a about a six-month allowance either way on reading age scores (Fawcett and Nicolson, 2004) but some of the children had scores greater than six months difference between the tests. Both tests were completed within a month of each other so differences between the reading ages are not due to the timing of the tests. One possibility is that the children were using particular strategies to read which was successful in one type of test but not the other. Another possibility is that because the percentile scores are so low that the tests have a higher degree of measurement error in children who have extremely low scores.

The top three readers were also the top spellers, with only one of the poorer readers (Harry) having a typical percentile score of twenty-five. Only two of the children (Lewis and Beth) correctly spelt more than eight words, as there appeared to be a clear cut-off for the children in the test. The first eight words in the spelling test were made up of single syllable words with simple cvc (consonant, vowel, consonant) or conventional letter patterns. The remaining twenty-four words were mostly multi-syllabic with increasingly complex blends and non-regular letter groups. All of the children were able to spell some words including Will, who had not scored well on the reading tests, showing he was able to use phonological knowledge to build up spellings, but not to decode reading (Caravolas et al, 2001).

All of the children had difficulties with the handwriting test. It was to be expected that the children would score poorly in this test as the quality of their handwriting would be impaired due to their poor coordination; however other difficulties became apparent as the children were completing their tests. The children generally managed the first word or two successfully, agreeing with the findings in a study of handwriting of children with CP by Bumin et al (2008), but their writing deteriorated and mistakes started appearing such as

forgetting to put spaces between the words. This may have been because the children began to get tired, even over a minute, and their concentration began to deteriorate; or it may be because they do not usually leave spaces between words in their everyday writing and they reverted back to their normal writing patterns.

#### Were there relationships between the literacy abilities?

There were higher scores in the nonsense passage test and the Salford reading test in comparison to the two listed word and nonword tests. This suggests that the children were able to use non-phonemic knowledge, such as grammar and syntax, to help them read passages of text, and when they were able to use this strategy their performance improved in relation to what would be expected at their age. Indeed, several of the older poorer readers had succeeded in reading larger numbers of words on these two tests suggesting that they were using multiple strategies, such as is proposed in the theories regarding the connectionist approach (Plaut, 2005).

The older children's use of phonological strategies involving letter/sound correspondences to decode words is consistent with suggestions by researchers (Asbell et al, 2010; Larsson, Dahlgren Sandberg and Smith, 2009) that children with CP use these strategies much longer than children without CP. Another possibility is that they reach the stage of being able to use phonological strategies much later than typical children as they are delayed in learning basic literacy skills. It might be that it takes longer for the children to get past the initial phoneme/ grapheme (partial-alphabetic, Ehri, 2002) phase before they are able to progress from naming letter/sound correspondences to employing these correspondences in blends. Older typical children generally have more experience of reading, and use other strategies such as chunking or analogy when decoding.



Apart from the inability of most of the children to spell the more complex words, the time limit of two minutes meant that several of the children were too slow at spelling the words to progress beyond the first eight words. Some children managed to attempt the first two-syllable word (morning) but only managed to spell the first two or three letters. Kandel et al (2009) suggest that the episodic buffer in the working memory system may be a cause of difficulty in multi-syllabic words while Dorman's (1985) participant had poor auditory encoding or poor auditory memory causing difficulties with phoneme/ grapheme processing. These spelling difficulties may also be due to an inability to apply phonics in specific positions (sequencing) within words (Berninger, 2009). The difficulties or delays in learning phoneme/ grapheme associations, which affected the children with their reading skills, also affected the children's spelling abilities.

Looking at all the samples of the children's handwriting, (see Appendix 3: Handwriting samples from the DST-J) they have all, apart from Joe, had difficulties with the evenness of letter shapes, spacing between letters and words, and correct punctuation where relevant. These types of errors are often seen in young children, who are just starting to write (Steffler and Critten, 2008), but fourteen of the children were over the age of seven when they completed the test and typically developing children would not be making these mistakes in their work (Bumin, 2008; 2010). The reading and spelling tests have suggested that many of the children are delayed in learning grapheme/ phoneme associations. Although there does not appear to be a simple or single link, as the better readers also had poor results, there may be some common factor which affects the development of these skills.

Thus, the literacy tests have shown that the majority of the children have severe problems with literacy. The generally poor results shown by the children have demonstrated areas of

weakness in developing the initial building blocks necessary to learn to read and write. However, the older children have used strategies to enable them to read and spell. A longitudinal study was utilized to see whether the children were able to build on their initial skills.

### Longitudinal Data

The longitudinal part of the study (see results in Tables 2.5 and 2.6) involved six children who were the first participants in the study from the first school. Two of the decoding tests were used to assess their progress over time: the one-minute reading test and the nonsense passage test which were given to the children at yearly intervals.

There were several notable features to the longitudinal findings. First, across the three time points the children usually made gains in their raw scores (number of words correctly read) showing that there was an increase in level of their reading abilities as the children became older. This is something that might be expected given increasing maturity and the educational support that the children received. In the longitudinal studies of Dahlgren Sandberg (2001) and Peeters et al (2009b) the children with CP did make improvements in their reading skills, but they were given words in their decoding tasks which they had to match with pictures, which would have been a much simpler task.

The second notable feature was that the more able readers had higher percentile scores on the nonsense word passage test than the one-minute reading test. Most of the children in this study showed improvement on the real words in the nonsense word passage test, although two of the children (Beth and Emma) were already at or near ceiling point. This suggests that the children still had problems with word recognition when there was no context or semantic information, and the children found it difficult to decode unknown

words (whether real or nonsense words) using phonological strategies. Dorman (1985) explained similar difficulties in his report, in that KS had difficulties with reading lists of words because she was unable to produce sounds of letters or groups of letters together (analogy) and Dorman suggests that KS had problems with her reading due to impaired working memory processes.

The third notable feature of the findings was that the two most able readers made considerable gains in their percentile scores across the three time points. In contrast, most of the poorer readers made smaller gains, and their percentile scores suggest that they continued to have very poor reading skills in comparison to typical children in their age group.

The findings from the longitudinal data also indicated that the children's performance remained reasonably consistent across the three time points as shown by the high, and sometimes significant, correlations between the percentile scores. These relationships suggest that the tests were providing reliable assessments of the children's literacy abilities. The children in the longitudinal study had a range of literacy abilities, and the correlations between the longitudinal scores increases confidence in the findings of the larger cross-section sample.

#### **2.4.1: Conclusion**

The assessments indicated that the majority of children with CP in this study had a range of severe literacy difficulties, with only three children out of the fifteen scoring consistently at typical levels in all the reading and spelling assessments. There was evidence that when the children were able to use contextual information their percentile scores were higher.

Most of the children had severe problems with spelling, and all the children had difficulties with the handwriting assessment.

The twelve children with reading difficulties might have been thought to be delayed in their literacy development because of general learning difficulties. This was unlikely because the children were selected because they were assessed as having typical learning abilities in subjects such as Science; even so it was an issue that was thought to need further examination. In the next chapter, there is an investigation into the children's cognitive abilities.

## Chapter 3: Assessing the abilities of the children

### **3.1: Introduction**

As indicated in Chapters 1 and 2, there are a number of reasons why children have difficulties with literacy (Vellutino et al, 2004; Snowling, 2008; Berninger, 2009; Hulme and Snowling, 2009). One of the reasons might be because the child has a general learning difficulty or a speech and language impairment as opposed to a specific reading difficulty, (Snowling, 1987; Byrne, 2005; Hulme and Snowling, 2009). The investigation reported in this chapter was designed to examine whether the presence of general learning and/ or language and communication difficulties could explain why many of the children with CP had poor literacy skills. The children were given a range of assessments of their non-verbal, verbal and communication abilities. A further assessment of the children's abilities was obtained from their SATs (Standard Assessment Tests: see Appendix 4) to give an overall picture of their school achievement (see Table 2.1, Chapter 2). If general learning difficulties are present then one would usually expect there to be an equally poor performance across all the ability measures; and for there to be highly positive correlations between all the areas of functioning (Hulme and Snowling, 2009). On the other hand, if the children have a more variable profile of abilities, these measures might indicate that the children have specific literacy difficulties (Snowling, 1987).

Previous studies of non-verbal abilities and language-related abilities were reviewed (Sections 3.1.1 and 3.1.2) to identify which assessments might be suitable for use with children who have CP. The most commonly-used assessments are matrices (non-verbal ability); measures of language ability such as communication skills and receptive vocabulary; and measures for semantic ability and the understanding of language. Researchers have commented on issues of methodology in relation to working with

children who have CP (Dorman et al, 1985; Dahlgren Sandberg and Hjelmquist, 1997; Beal et al, 2000; Sabbadini et al, 2001; Vandervelden et al, 2001; Larsson et al, 2008; Holck, Nettelbladt and Dahlgren Sandberg, 2009) and there is a discussion of some of the problems they encountered when testing children with disabilities (Section 3.4).

### **3.1.1: Nonverbal assessments**

One of the most commonly-used non-verbal assessments of intelligence is the Raven's Coloured Progressive Matrices (RCPM), (Raven, Raven and Court, 1998) which has been utilised in studies with children with CP in order to assess their ability levels and to match them with typical children, (Asbell et al, 2010; Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Holck et al, 2009; Jenks et al, 2007; Larsson et al, 2008; Peeters et al, 2008, 2009a, 2009b, 2009c; Pueyo, Junque, Vendrell, Naberhaus and Segarra, 2008). The coloured version of the Raven's Matrices was developed for younger children (aged up to 8 yrs in the 2008 version), elderly people, and people with physical disabilities or learning difficulties, and has been used in investigations regarding focalised brain lesions (Gainotti, D'Erme, Villa and Caltagirone, 1986). They have also been employed in assessing the abilities of children with specific language impairment (SLI) and developmental coordination disorder (DCD) (Packiam Alloway and Archibald, 2008). Another version has been developed for use with older individuals and this has been used with children who were considered to be of typical abilities (Bishop et al, 1990; Beal, Zeitz, Connell and Zschorn, 2000; Gainotti et al, 1986) or aged over eight years (The Psychometrics Centre, 2010). The standardised version was used in this study as the children were of the appropriate age for the calculation of percentile scores, and the majority of the children were aged over eight years.

Other studies on children with CP have used Raven's Matrices along with other measures, in general the Matrices' scores correlate positively with other assessments such as, respectively: speech and language abilities (Bishop et al, 1990); verbal and visuo-spatial abilities (Pueyo et al, 2008); and better at the prediction of comprehension abilities (Asbell et al, 2010).

### **3.1.2: Verbal assessments**

Another important area of functioning involves the language-related abilities of children with CP. Previous research (Bishop, 1985; Bishop and Robson, 1989; Bishop et al, 1990) has suggested that a number of verbal children with CP have language abilities appropriate to their chronological age. It was decided to use the Communication Checklist that has been produced to measure the general communication abilities of children (Children's Communication Checklist: CCC2, Bishop, 2003). Many nonverbal children with CP have difficulties because of poor muscle control affecting the areas around the mouth, but their functional and pragmatic language skills are not necessarily impaired (Dahlgren Sandberg et al, 1997; Dahlgren Sandberg, 2001).

Vocabulary is a key component of the language system and a commonly-used language test for children with CP assesses receptive vocabulary. In these assessments, children are usually given pictures and a spoken word and have to pick out the appropriate picture that corresponds to the word. The Peabody (PPVT) (Dunn and Dunn, 1997) and the British Picture Vocabulary Scale (BPVS) (Dunn, Dunn, Whetton and Pintile, 1982) have been used in studies to assess vocabulary abilities and are especially useful when children have no or little spoken language (Asbell et al, 2010; Basil and Reyes, 2003; Beal et al, 2000; Bishop, 1985; Bishop et al, 1990; Holck et al, 2009; Jenks et al, 2007; Larrson et al, 2008; Peeters et al, 2008, 2009c; Vandervelden et al, 1999, 2001). Many of these researchers used both the

RCPM and the receptive language test in their studies but both tests were mainly utilised in order to match with controls rather than to determine the general level of functioning of children with CP. To assess the receptive vocabulary of children in this sample, it was decided to use the DST-J (2004) as the test was available and it was possible to use several assessments from this battery of tests.

Because many children with CP have speech difficulties due to dysarthria or poor muscle control, there have been a small number of studies which have involved other areas of language, such as the grammatical, semantic and pragmatic understanding of language (Asbell et al, 2010; Bishop et al, 1990; Dahlgren Sandberg et al, 1997; Dahlgren Sandberg, 2001; Holck et al, 2009). A variety of tests were used in these studies including the Renfrew Bus Story Test and the Children's Communication Checklist, (Bishop, 2003), and the Test for the Reception of Grammar (TROG), (Bishop, 1982). Generally, the studies had somewhat mixed results. The children with CP compared well with typically developing children for comprehension (Asbell et al, 2010) and grammar construction (Bishop et al, 1990), but poorly in comparison to typically developing children in other measures.

One study by Holck et al (2009) used all of the above measures in their investigation into the pragmatic abilities of children with CP in comparison to children with Spina Bifida and pragmatic language impairment. They found that, generally, children with CP were very similar to children with Spina Bifida in a number of comprehension tests, but children with CP found two tests more problematic – the story recall test of the Renfrew Bus Story, and the short-term memory test. The CP-group's scores had significant correlations between inferential and literal comprehension; the CCC and story recall, and this was the only group that had these correlations. Holck et al suggest that children with CP may have difficulties with language comprehension, particularly with receptive vocabulary, and his findings



regarding comprehension replicated those of Dorman (1985). However, in the latter case Dorman reported that the difficulties with comprehension may have been caused by reading difficulties, while Holck (2009) attributed this to problems with testing the participants. In this thesis, it was decided that the children would be verbally tested on two semantic/ comprehension tests to prevent the reading comprehension difficulties reported by Dorman. One test, made up of two parts, asked children to give the meanings of individual words, followed by the second part where the children had to select an alternative word with the same meaning from a group of six or eight words. The second semantic test asked children to name as many words as possible within a specific category.

### **3.1.3: Adaptations of tests and the use of comparison groups**

In previous studies of children with CP, there have been difficulties with using some standardised tests due to the nature of the children's disabilities. Many researchers adapt standardised tests to overcome the difficulties of testing, (Dorman et al, 1985; Dahlgren Sandberg and Hjelmquist, 1997; Beal et al, 2000; Sabbadini et al, 2001; Vandervelden et al, 2001; Larrison et al, 2008; Holck et al, 2009) but often they have concluded that the children had accessibility problems with the tests which may have affected the findings, such as speech and language difficulties or problems with indicating answers. In the case of literacy tests there is an expectation that children can read questions or write answers and this may be unrealistic for this population of children.

Another issue in previous studies has been the identification of suitable comparison groups. This has been particularly problematic as it has been difficult to find typical children without CP but with similar test scores. In their investigation of the phonological awareness of non-speaking children with CP, Card and Dodd (2006), based in Australia, assessed the non-verbal abilities (Raven's CPM) of two groups of children with CP aged

between 6 yrs and 12 yrs. In order to find children with similar raw scores to act as controls, Card and Dodd had to find children (in England) aged between 4 and 5 years old who obviously differ from the children with CP in many other respects. Another study where there were discrepancies involved 8 people with CP between the ages of 9 and 30 years of age. Sabbadini et al (2001) matched the CP group with 19 controls using mental ages from the PPVT (Dunn and Dunn, 1997) which were between 3.4 and 6.2 years and chronological ages between 3.6 and 6.6 years. As in Card and Dodd's study, results were varied which may have been due to the ages of some of the controls. Many of the tests had to be modified to make them accessible to the CP group as they had poor verbal speech as well as severe physical impairments.

### **3.2: Study 2: Assessing the abilities of children with CP**

In this thesis, standardised tests were selected for their accessibility and ease of use to ensure they did not put too large a burden on the children (see the ethics section in Chapter 1), and the participants in the study had sufficient verbal and visual abilities to access the tasks (see list of criteria for participants in Chapter 2). In this thesis, having a special school teacher as the researcher has been an advantage as personal knowledge of the children enabled the timing and application of the tests to be a positive experience. For example, the visual perception tests (Chapter 5) were interspersed with vocabulary tests as several of the children found looking at visual patterns for the length of the test quite tiring. Protocols for testing were followed as instructed by the designers of the tests.

To summarise: in order to assess the capabilities of the children, a number of tests were utilised which measured both communication and language (verbal) and non-verbal abilities.

## Questions

### 3.1. Did the children with CP have general learning difficulties

### 3.2. Did the children's non-verbal, communication and language abilities relate to their literacy abilities?

Because most of the children had low scores of reading, spelling and writing assessments, it is possible that these difficulties were due to a general learning disability or general language and communication difficulties (Snowling, 1987; Byrne, 2005; Hulme and Snowling, 2009). If this explanation is correct then one might expect most of the children to have low scores across most or of all the tests of non-verbal ability, verbal ability, communication and the SATs results. If the tests reveal typical levels of ability in most of the children, then this will indicate the presence of a more specific cognitive difficulty that could affect literacy development.

#### **3.2.1: Method**

The participants and conditions of testing are as previously described in Chapters 1 and 2. A battery of tests was given to the children encompassing different types of cognitive tests: non-verbal, verbal and communication assessments. The non-verbal test consisted of black and white matrices; while the verbal tests consisted of a receptive language test and two semantic tests. There is a communication assessment consisting of a range of expressive abilities.

#### Test 3.1: Raven's Standard Progressive Matrices

The Raven's Standard Progressive Matrices (SPM) (Raven, Raven and Court, 2008) was utilised as the majority of the children are aged over 8 years. The test consists of five sections, each involving twelve problems relating to images and shapes in which the problems become progressively harder. The raw scores derived from the correct answers in each section can be converted into standard scores and percentiles.

### Test 3.2: The Children's Communication Checklist (CCC2)

This assessment (Bishop, 2003) was designed to evaluate the communication abilities in children between the ages of four to sixteen years. The test has been designed for caregivers to evaluate whether children are socially or cognitively affected by language or vocabulary difficulties such as in autism or SLI. However, caregivers may show not show impartiality when assessing their own children. In order to use the test as a research instrument, the assessments were carried out by a single researcher to ensure continuity across the participants and increase reliability (Cohen, Manion and Morrison, 2000). The test is made up of two sections: one containing fifty statements relating to difficulties with communication; and another section of twenty statements relating to strengths with communication. Each statement has to be marked with a number which best describes the child's the child's communication ability. The marks are as follows:

- Never, or less than once weekly: 0
- Over once a week: 1
- Once or twice daily: 2
- Always or more often than twice daily: 3.

The sections of statements are divided into specific categories which are : speech; syntax; semantics; coherence; inappropriate initiation; stereotyped language; use of context; nonverbal communication (eye-gaze and gesture); social relations; and interests (obsessions). The scores are added together to give a percentile score of communication ability.

### Test 3.3: Receptive Vocabulary

This assessment (from the DST-J, 2004) was used to measure receptive vocabulary in a multi-choice format and is similar to the BPVS (British Picture Vocabulary Scale, Dunn et al, 1982). The child has to pick out one picture from four that most clearly matches a given word. While the initial words are nouns, some of the latter words are included to assess

reasoning skills, e.g. 'habit' (a picture of a nun's outfit) may not be known to children but they can reason that the word does not apply to the other pictures of a dress, a man's suit or a suit of armour. A practice test is given, after which the main test is started.

The test can be given to a whole class, where the children can mark their choices of pictures, or can be completed individually with a child, which was the method used in the present study, where the child can just point to the selected picture. The scoring is a mark for each correct picture with a maximum of 16 marks.

#### Test 3.4: Mill Hill Vocabulary Scale

The Mill Hill Vocabulary Scale (Raven, Raven and Court, 2008) assesses semantic abilities or the children's understanding of the meanings of words, and is organised into two sections. In the first section a number of words are provided, where the children have to write the meanings in their own words. In the second section the words are provided alongside six further words, only one of which gives a correct meaning, e.g. the word 'toss' comes with 'throw, catch, hide, roll, dive, pull'. The two sets of results are added together to give a total score which is expressed as a percentile scoring and an age equivalent and reflects the semantic abilities of the children. In all cases, the test was given orally so that children who were unable to read or write were not disadvantaged, therefore caution must be exercised when interpreting the percentile scores.

#### Test 3.5: Semantic Fluency

This is a test from the DST-J (Fawcett and Nicolson, 2004) which assesses children by their ability to say names of things within a category such as food in the practice trial, or animals in the main test. Thus the test involves an assessment of the children's ability to produce as many words as possible from the same semantic category. The time is limited to one minute and the scoring is one mark for each valid animal's name. Due to the difficulties that most of the children had with writing, all of the children dictated their answers, and again, caution must be exercised when interpreting the children's percentile scores.

### 3.3: Results

This section contains the percentile scores of the tests of non-verbal, verbal and communication ability. Coloured cells in the table indicate scores which are in the typical ranges of above the 24<sup>th</sup> centile. The children have been put in the same order as those of the literacy tests, with the best readers at the top of the table to enable comparison.

Table 3.1: Percentile scores of all the tests

Name	Ravens	CCC2	Rec vocab	Mill Hill	Sem flu
Ian	0.1	95	8	25	30
Lewis	5	70	65	84	95
Beth	0.4	84	50	37	25
Garth	9	45	25	37	35
Joe	25	52	50	63	95
Harry	0.1	74	50	50	20
Emma	1	21	55	9	8
Cleo	5	60	22	16	75
Linda	5	70	25	37	25
Amy	0.1	18	40	37	91
Chris	0.1	10	15	25	15
Rob	1	74	20	16	10
Lee	1	79	65	37	50
Jon	0.1	9	22	25	22
Will	0.1	82	30	50	20
Means	3.53	56.21	36.13	36.53	41.07
SD	6.52	28.9	18.5	19.5	31.86
No of typical scores	1	11	10	12	9

The results of the ability assessments, in Table 3.1, show that there is a wide disparity between the percentile scores of the Raven's non-verbal test and the percentile scores of the verbal and communication tests. Only one child scored at the 25<sup>th</sup> centile in the Raven's Matrices test while all the other children scored below the 9<sup>th</sup> percentile. The better readers, at the top of the table, had low scores in common with the poorer readers.

These extremely low scores would appear to indicate that the children have learning difficulties in the severe range.

In contrast, the percentile scores of the verbal and communication assessments indicate that the majority of the children have typical (or above) abilities with language and communication. Several of the children had scores above the 75<sup>th</sup> centile. The results of the communication test (CCC2) were relatively good with many of the children scoring above the 50<sup>th</sup> percentile, with a mean score of 56.21, suggesting that communication is a strength for these children. However, not all the children scored highly in all the tests and, overall, only six of the children had typical scores in all the verbal tests. Many of the standard deviations of the ability tests are quite wide showing the range of scores is diverse apart from the matrices' test where the standard deviation is only 6.52.

Table 3.2: Correlations between assessments for non-verbal ability and language assessments

	Raven's Matrices	CCC2	Receptive Vocabulary	Mill Hill	Semantic Fluency
Raven's	x	-0.074	0.291	0.156	0.462
CCC2	x	x	0.108	0.24	0.006
Receptive Vocabulary	x	x	x	.536*	0.299
Mill Hill	x	x	x	x	0.513

\* Correlation is significant at the 0.05 level (2-tailed)

Looking at Table 3.2, only one of the correlations was significant, and all but three of the correlations were weak (rho below 0.3). This suggests that there was a lack of consistency in the children's performance across the tests. The only significant correlation was between the Mill Hill test and the receptive vocabulary test. There also were two moderate non-significant correlations of above 0.4; between the Mill Hill and the semantic fluency test, and between the semantic fluency test and the Raven's Matrices. Thus, the

lack of significant associations between the verbal cognitive tests and the Raven's matrices indicates that the children's performance could not be attributed to a general learning impairment.

**Table 3.3: Correlations between the literacy and ability assessments**

	1 minute reading	Nonsense passage	Salford reading	TVTC nonword	Spelling test	Hand writing
Ravens matrices	0.298	0.157	0.178	0.07	-0.035	0.201
CCC2	0.285	0.184	0.121	0.372	0.225	-0.008
Receptive vocabulary	0.231	0.183	-0.124	0.15	0.006	0.114
Mill Hill	0.312	0.129	0.272	0.191	0.258	0.2
Semantic fluency	0.425	0.248	0.462	0.092	0.099	0.208

Table 3.3 shows the correlations between the literacy and ability percentile scores. There were no significant correlations between the scores on the literacy tests with the non-verbal ability and speech and language tests. This suggests that the children's literacy abilities were not related to either their non-verbal abilities or language abilities. There were two moderate correlations which were above .4; between the semantic fluency test and the one-minute reading test and the Salford reading test, but they were not significant.

### **3.4: Discussion**

The objective of this part of the investigation was to find out whether the children's non-verbal, verbal and communication abilities help us understand why most of the children performed poorly in the literacy assessments.

Looking at the scores for the non-verbal assessment – the Raven's Standard Matrices in Table 3.1– all of the scores, apart from one at the 25<sup>th</sup> centile, are below the 10<sup>th</sup> centile and most are below the 5<sup>th</sup> centile with a mean score of 3.53. These results appear to



suggest that the children have very poor reasoning and analytical skills (Carpenter, Just and Shell, 1990; Pueyo et al, 2008). Pueyo et al suggested that as the Raven's matrices involve the analysis and manipulation of patterns; the poorer the visual-spatial abilities of the participant, the worse will be their score on the Raven's test. Other studies of children with CP (Dahlgren Sandberg, 2001; Peeters et al, 2009a) have indicated that poor non-verbal abilities can also signal poor literacy development and poor memory abilities. One might therefore conclude that the children had poor literacy abilities because they have poor non-verbal abilities. However, the scores on the Raven's test were extremely low and tended to be lower than the children's literacy abilities and even the children with typical literacy abilities achieved low scores on the Raven's matrices. There were weak correlations between the Raven's test and the literacy tests suggesting that the children's non-verbal abilities were not related to their literacy abilities.

There was a marked difference in scores between the non-verbal and verbal and communication tests. Looking at Table 3.1, the scores for the receptive vocabulary test indicate that ten out of the fifteen children performed above the 25<sup>th</sup> centile, with a mean score of 36.13. This suggests that most of the children had typical receptive vocabulary abilities. There were similar findings from the two semantic tests. These two tests had the highest mean percentile scores (the fluency task at 41.07 and the Mill Hill at 36.53) showing that the majority of the children had a typical semantic understanding of language, although five of the children scored below the 25<sup>th</sup> centile in the fluency test, and three scored below the 25<sup>th</sup> centile in the Mill Hill test. The only child who scored below the 25<sup>th</sup> centile on all the verbal scores was Rob. All of the other children either scored well on the receptive vocabulary test or the semantic test or on both tests. Thus the results of all the verbal tests indicate that the children's literacy difficulties are unlikely to be due to speech and language impairments.

When comparing the Raven's Matrices test with the receptive language test, the results were in agreement with previous studies where the children with CP performed much better on the receptive language assessments than in the cognitive non-verbal tasks. In Bishop et al's (1990) study there was a wide discrepancy between the results from the Raven's test, which was below the 5<sup>th</sup> centile, and the receptive language test (BPVS). The children with CP in both studies were far more able in the receptive vocabulary assessments despite half the children in Bishop et al's test having little or no spoken language. Most of the children in this study had typical communication skills and language abilities.

#### **3.4.1: Conclusion**

The standardised assessments have provided data to support the following interpretations:

1. The Science results at Key Stage 1 and 2, described in Chapter 2, indicate that the children are working at typical or just below typical levels.
2. The standardised tests in Study 2 (this chapter) indicated that the children had strengths in their verbal and language skills.
3. The children performed very poorly in the Raven's non-verbal test. It would normally be assumed that the children's poor analytical and reasoning skills (Carpenter et al, 1990; Pueyo et al, 2008) might indicate a learning difficulty that could explain their poor literacy development. However, the children who did well in the literacy tests also performed poorly in the Raven's Matrices test which suggests that the nature of the test was difficult for children with CP. One possibility is that the tests require the children to have good visual perception (Courbois, Coello and Bouchart, 2004) to be able to manipulate the patterns in the matrices (see Appendix 5 for correlations between the cognitive scores).

4. The performance on the non-verbal and language tests did not appear to be related to the literacy abilities of the children, either in terms of overall profiles or in terms of correlations.

As the children did not appear to have general learning difficulties, the next three chapters will investigate whether the children have specific difficulties with:

- phonological processing, which may affect their development of literacy skills;
- visual and spatial perception, which might affect their ability to process the shapes of letters or words;
- working memory, which would affect the speed of the children's processing and speed of working.

## **Chapter 4: Phonological Processing in children with CP**

### **4.1: Introduction**

Phonological abilities and processing are known to be linked with literacy, particularly decoding, moreover it is believed that impaired phonological awareness and representations are an inherent feature in dyslexia (Vellutino and Fletcher, 2005; Snowling, 1987, 2008; Frith, 2002; Ehri, 2002, 2005; Hatcher and Snowling, 2002; Apel, 2009; see also Chapter 1). Different aspects of phonological development have been linked to or identified as precursors to literacy abilities, such as knowledge of letter/ sound representations; onset/rime; grapheme/ phoneme correspondence; and orthographic and morphological knowledge (Hulme and Snowling, 2009).

Researchers of children with CP with communication difficulties or speech and language impairment have indicated that these children are more likely to have phonological processing difficulties in comparison to typical children (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008; Bishop, 1985; Bishop and Robson, 1989; Bishop et al, 1990; Card and Dodd, 2006; Peeters et al, 2008; Vandervelden and Siegel, 1999, 2001; Hart et al, 2007). Some of these studies have included children with CP, who are able to speak, as comparison groups (Bishop and Robson, 1989; Bishop et al, 1990). However, the findings from these studies are inconsistent; consequently it is not clear whether children with CP, who can speak, do have phonological deficits. The study in this chapter is a means of contributing further knowledge to this area of research.

Three topics are explored in this introduction: firstly, whether children with CP, both those with typical verbal abilities and those with speech and language difficulties, have

phonological difficulties; secondly, whether relationships have been found between the phonological abilities and the literacy abilities of children with CP; lastly findings concerning standardised tests, which measure phonological awareness and processing are outlined, particularly those which have concerned children with CP.

#### **4.1.1: Children with CP and phonological abilities**

Many children with CP are able to verbally express themselves at a level appropriate for their age in that they can ask or answer questions or make comments, but have breath control problems such as dysarthria which may affect the quality of their vocal output (Bishop, 1985). The children may take longer to produce words or the words may be slightly, or more severely, inarticulate. Several investigations have been concerned with the question of whether impaired speech and language output in children with CP results in impaired development of phonological abilities (Bishop, 1985; Bishop and Robson, 1989; Bishop et al, 1990; Card and Dodd, 2006).

Bishop and Robson (1989) compared children with CP with dysarthria with two control groups: children with CP who could speak; and children with similar mental ages. Bishop and Robson tested the children for phoneme awareness, by asking them to spell words and non-words. They came to the conclusion that there was little difference in phonemic awareness between the samples. In a later study, (Bishop et al, 1990) compared children with CP who were non-verbal and those who could speak in a test for phoneme discrimination using a same/ different task. Bishop et al concluded that the children with CP who could talk had better phonemic discrimination than those who had speech impairments. Card and Dodd (2006) came to similar conclusions to Bishop et al's (1990) study. Card and Dodd suggested that an inability to speak affected some aspects of phonological processing: phoneme detection, phoneme manipulation and phoneme/

grapheme conversion. Furthermore, in the latter study the children with CP who could speak had poorer performances than the control groups of typical children with similar mental ages.

There also have been a number of studies that have focused on children and adults with CP who do not speak or who have limited verbal speech. These participants use AAC (Augmentative and Alternative Communication) high-tech devices such as Dynavox electronic talkers, or low-tech devices such as books with Boardmaker or Rebus symbols. Groups of AAC users have been studied to establish whether their use of symbols or a lack of verbal output may have affected their phonological processing. However, the findings from these studies differ. For example, Dahlgren Sandberg has reported that Swedish children with CP performed comparably with their control groups of similar mental age in phonological awareness tests (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001). In contrast, researchers of a Canadian study found that groups of children with CP performed less well in comparison to typical control groups, who were matched by their reading ages (Vandervelden and Siegel, 1999; 2001).

#### **4.1.2: Phonological processing abilities and literacy**

Dahlgren Sandberg (2001) compared the reading and spelling abilities of children with CP who were unable to speak, in relation to children with similar mental ages but typical development, in a longitudinal study of three time points. At each time point the CP group's reading abilities were below their phonological abilities, particularly in the phonological segmentation tests. Over the course of the study, in comparison to the typical children, the children with CP made much slower progress in literacy at all the time points. These results indicate that while the children with CP had initial phonological

abilities similar to those of typically-developing children these were not sufficient to help them to develop their subsequent reading and spelling skills.

In studies, where participants have included children with CP with intelligible speech (Bishop and Robson, 1989; Bishop et al, 1990; Dorman,1985; 1987) the children have been found to have difficulties with phonological processing although there were some inconsistencies in the findings. KS (Dorman, 1985) had phonological awareness difficulties which were comparable to her literacy difficulties. The young people in Dorman's 1987 study were tested on phonemic discrimination but there were weak correlations between the test scores and the children's literacy abilities. Thus, there is not a clear picture regarding the children's phonological awareness or processing abilities as different tests were used, and sometimes adapted, in the studies.

Therefore, there is evidence that, generally, children with CP or with developmental cognitive difficulties such as dyslexia (see Hulme and Snowling, 2009) have poor phonological awareness, in comparison to typical children with similar mental and chronological ages. This is likely to lead to difficulties with the development of phoneme/grapheme associations. Delays in developing stable representations may affect the ability to recognise or decode words when reading (Apel, 2009), or the ability to build up letter sounds and blends when spelling and writing (McBride-Chang, 1995). However, there is a lack of evidence about whether the phonological awareness of children with CP is related to their literacy abilities.

#### **4.1.3: Standardised phonological assessments**

There are a range of standardised tests to assess phonological awareness and coding, and the ability to manipulate phonemes. Three different phonological assessments were

utilised in this investigation: phonological manipulation or segmentation; alliteration fluency; and rapid naming (RAN). These types of tests are described below.

Phonological manipulation, or phonemic segmentation, is one of the measures most often used in phonological assessments (Castles, Holmes, Neath and Kinoshita, 2003; Hatcher and Snowling, 2002). It comprises the detection and isolation of single sounds, phonemes, syllables or orthographic units, and its deletion from an original word. It relies on the participant being able to perceive individual, quickly-presented sounds within words (input phonology), and the ability to manipulate those sounds and produce a word without the identified constituent (output phonology, Snowling, 1987). Generally there is a correlation between children's learning abilities, reading and spelling abilities and their phonological processing abilities (Caravolas et al, 2001; Goswami, 1999).

It is usually assumed that the association between phonological impairment and literacy difficulties is because delays or problems in the acquisition of phonological awareness may impede the development of reading and spelling skills. However, in terms of the phonological manipulation test, poor reading abilities may disadvantage children (Castles et al, 2003). Although the test is verbally presented, one strategy used to complete the test might be to visually imagine manipulating the phonemes or orthographic units within word, which relies on the ability to be able to visualise or hold the whole word within the memory (McBride-Chang, 1995). Castles et al suggest that knowledge of orthographic information will substantially affect performance on a phonological processing test.

Alliteration, rhyme and verbal fluency tests assess whether children can identify words with similar sounds (usually the first or last phoneme of a word). These are usually considered to be measures of phonological awareness (Goswami, 1999). Children play this in I-spy



games but it is often used in schools when teaching identification of initial phonemes to use for reading and spelling. Rhyme and alliteration knowledge necessitates the ability to be sensitive to sounds in words (McBride-Chang, 1995; Hatcher and Snowling 2002) but also to be able to concentrate or focus on particular sounds. Goswami (1999) discusses the necessity for teaching onset/ rime as she considers it to be an important aspect of not only learning to read, but learning to spell. Understanding the concept of onset/ rime means that children may be able to use analogy not only to help them recognise, and decode components of words but also to help them recognise spelling patterns. Verbal fluency also can involve phonological awareness when children are required to produce as many words as possible that begin with the same letter or sound, although it is possible that the task may also involve other abilities such as working memory.

Another aspect of phonological processing concerns the production of speech in order to name a symbol, picture or word. Children with deficient rapid automatized naming (RAN) skills are often found to have poor literacy abilities (Wolf and Bowers, 1999; Hulme and Snowling, 2009). However, there is uncertainty about what is the reason for these connections. Some researchers such as Wolf and Bowers (1999) argue that RAN is not a phonological measure but a measure of speed of processing visual information, while Hulme and Snowling (2009) regard it as a measure of phonological ability. In Lervag and Hulme's (2009) study of pre-readers in Norway, RAN was measured as part of a three year longitudinal study into predictors of literacy development. They found that RAN predicted later reading fluency, and speculated that this was due to neural circuits, involved in object recognition and naming, also being involved in visual word recognition. Mental orthographic representations, or visual representations of the whole word, are reported by Apel (2009) to be an important aspect of learning to read. His study supports Lervag and

Hulme's findings in that RAN measures the ability to identify whole words rather than relate to only phonological processing skills.

In the study described below, the children were all evaluated using standardised tests of phonological processing: a phonemic segmentation test, a test for verbal fluency and a test for RAN in order to assess the extent of their abilities. Percentile scores were used to compare their performance with that expected of typical children of a similar age, and to allow comparison between the children themselves. Statistical analyses were conducted to examine whether the children's phonological abilities were related to their literacy abilities. It was hypothesised that if poor phonological abilities were a major cause of the literacy difficulties of children with CP, then those children with poor literacy abilities should also have poor phonological abilities. In addition, this relationship should result in significant correlations between the scores of the literacy tests and the phonological tests.

#### **4.2: Study 3: Phonological processing abilities in children with CP**

##### **Questions**

- 1. Do children with CP have difficulties with phonological processing?**
- 2. Are the children's phonological abilities related to their literacy abilities?**

##### **4.2.1: Method**

###### **Test 1: Phonemic Segmentation**

The phonemic segmentation test (from DST-J) was utilised to identify whether children are able to manipulate phonemes or syllables in known or common words. The test consists of a list of twelve words which are manipulated in different ways, starting with easy manipulations, e.g. what is left of the word football if ball is taken away? The DST-J manual (Fawcett and Nicolson, 2004) advises that children who are unable to complete this test'

should be given a rhyming subtest where children are asked to identify whether a couplet of simple words rhyme, e.g. pen and pet. The subtest is not scored but can be used as a diagnostic tool, for example, whether a child identified the rhymes but not the non-rhymes or vice versa. It was decided that all the children would complete this test, regardless of their scores on the phonemic segmentation test, in order to be able to make comparisons within the group.

#### Test 2: Verbal Fluency

The verbal fluency test (from DST-J) consists of asking the child to name as many words as possible beginning with a single letter 's', within a minute, after doing a practice test. The scoring is one mark for every correct word which is not repeated.

#### Test 3: Rapid Naming

This test (from DST-J) consists of a card with 40 images of common objects, for example, book, boat, tree; in which the first twenty images are repeated on the second half of the card. There is practice time in which the test administrator names the first twenty pictures for the child and indicates the order of naming, i.e. left to right and from top to bottom. The child starts from the first picture to the end and is timed for completion. At the end the scoring takes into account the length of time taken in seconds, any mistakes made, for which five seconds is added for each one, and an additional ten seconds is added if the child needs a card to help keep their place along the rows.

### **4.3: Results of Study 3**

As in the previous two chapters, the children's scores have been ranked from the best decoder in the one-minute reading test to the poorest. The cells have again been coloured to show the scores which are above the 25<sup>th</sup> centile.

Looking at the phonemic segmentation test first in Table 4.1, the results generally show that, as predicted, the better readers have the higher scores, with the two best readers having the highest scores at the 80<sup>th</sup> and 65<sup>th</sup> percentiles. There are two anomalies with the third best reader having a very low score, while one of the poorer readers had a typical score. Overall, however, the poorest readers had the poorest phonological segmentation results, and some of these percentiles were very low.

Table 4.1: Percentile scores from the three phonological tests

	Phonemic segmentation	Verbal fluency	Rapid naming
Ian	80	30	1
Lewis	65	35	61
Beth	6	55	15
Garth	35	2	9
Joe	35	55	45
Harry	6	10	5
Emma	10	3	95
Cleo	10	50	8
Linda	1	2	1
Amy	15	10	4
Chris	35	10	2
Rob	4	8	1
Lee	5	13	1
Jon	8	3	30
Will	5	10	1
Means	21.3	19.7	18.6
SD	24.1	19.8	27.9
Typical	5	5	4

The three best readers all had typical scores on the verbal fluency test while all the poorest readers, apart from one, had low scores, mostly below the 10<sup>th</sup> centile. The results of the rapid naming test were the most inconsistent in relation to both the other assessments of phonological abilities and in relation to the children's decoding abilities. However, overall the findings mostly showed that the poorest readers had the slowest RAN times. Informal observations suggest that part of the reason for these inconsistencies could be

that many of the children were slightly slower at speaking than typical children, and this appears to be mostly due to slight problems with breath control. It is also worth noting that Ian and Garth both have hesitancies in their speech which may have resulted in their lower scores.

Table 4.2 shows whether the children could identify that the pairs of words rhymed or did not rhyme. The coloured cells indicate the correctly identified pairs, and the last column gives the number of correct pairs out of a total of eight.

Table 4.2: Raw scores of the rhyme sub-test

	leg/ hen	pin/ win	cup/ pup	hop/ doll	toe/ toad	mud/ bud	peg/ pet	wing/ sing	Total /8
Ian									6
Lewis									8
Beth									7
Garth									6
Joe									8
Harry									5
Emma									8
Cleo									8
Linda									5
Amy									8
Chris									8
Rob									4
Lee									8
Jon									4
Will									3

Seven of the fifteen children were able to correctly identify all the couplets of rhyming words and the couplets of non-rhyming words, however there were some difficulties for the rest of the children. These seven children were the older children in the group, and they were stable in their identification and knowledge of rhyme, but certain pairs of words made many of the children hesitate over their decisions. The results of the two poorest readers appeared to show that they understood rhyme as they mostly correctly identified

the rhyming pairs, but in fact they identified all the pairs of words as rhyming which gave a skewed result. Thus they had an unstable knowledge of rhyme. Ian, Harry and Linda also had difficulties with the non-rhyming words.

Table 4.3: Correlations between percentile scores from the three assessments of phonological abilities

	Phonemic segmentation	Verbal fluency	Rapid naming
Phonemic segmentation	x	x	x
Verbal fluency	0.322	x	x
Rapid naming	0.445	0.166	x

Table 4.3 shows that there were no significant correlations between the scores of the different assessments involving phonological abilities; the highest non-significant correlation was between the phonemic segmentation test and RAN ( $\rho=0.45$ ). This suggests that the individual tests were assessing different aspects of phonological abilities and helps to justify the choice of a range of assessments.

Table 4.4: Correlations between phonological and literacy percentile scores

	1 Min Reading	Nonsense Passage	Salford Reading	TVTC Nonword	1 min Spelling	1 min Writing
Phonemic Segmentation	<b>.590*</b>	<b>.720**</b>	<b>.737**</b>	0.42	<b>.538*</b>	0.034
Verbal Fluency	0.369	0.389	0.458	<b>.570*</b>	0.326	0.387
Rapid Naming	0.431	0.448	0.364	0.2	0.383	0.476

\* Correlation is significant at the 0.05 level (2-tailed)

\*\*Correlation is significant at the 0.01 level (2 tailed)

There were significant and highly significant correlations between the phonemic segmentation test and the reading and spelling tests, (see Table 4.4) with particularly high correlations with the nonsense passage and Salford tests. The verbal fluency test had mostly weak to moderate correlations with all the literacy tests, although there was one

significant correlation with the TVTC test. The rapid naming test had no significant correlations with the literacy assessments, however several of the correlations were of moderate strength, being above 0.4.

#### **4.4: Discussion**

The first question addressed in this chapter concerned whether the children with CP in this sample had phonological processing difficulties. The assessments showed that, out of the fifteen children, only two children scored within the typical range of abilities across all three of the phonological tests. Generally the better readers had the higher scores in the phonemic segmentation and verbal fluency tests, but it was noticeable that the RAN tests were difficult for several of the better readers.

There was a wide range of percentile scores in the phonemic segmentation test, with only five children scoring within typical ranges. Generally the better readers scored the highest but one child (Beth) had a very low score. Young children with dyslexia (Hatcher and Snowling, 2002) are considered to be better at manipulating chunks or segments of words such as syllables, rather than perceiving and manipulating single phonemes or fine-grained elements of phonological coding. The initial section of the phonemic segmentation test required children to manipulate chunks of words such as isolating ball from football, which most of the children with CP were able to complete. However, the latter part of the test involved the manipulation of single phonemes, or fine grained elements, which children with dyslexia and many of the children with CP found very difficult (McBride-Chang, 1995; Hatcher and Snowling, 2002). Parts of the rhyme subtest proved difficult for many of the children particularly the pairs of non-rhyming words with dense phonology (described by Nunes, Bryant and Bindman, 1997) where the initial phonemes were the same and the children had to identify a non-rhyme by the final phoneme. The toe and toad non-rhyme

pair caused the most problems for the children and even some of the better readers were unable to identify whether the pair rhymed or not.

Many of the poorest readers in this study also had difficulties with the verbal fluency test. Although it is considered to be a phonological test in that the children need to identify the initial letter sound of words, it also requires children to retrieve words from memory with that initial sound. The children may have a dysfunction involving the relations between aural stimuli and spoken output (McBride-Chang, 1995; Snowling, 1997; Goswami, 1999; Hulme and Snowling, 2009) in that the children are either unable to perceive the initial sound and repeat it, or they are unable to produce words with that initial sound. Some of the children were able to produce a few words with the initial sound and then either gave up saying they could not think of any more, or produced lots of words with an incorrect initial sound. One possibility is that this is a retrieval difficulty similar to that in children with WFD: word finding difficulties (Dockrell, Messer and George, 2001) so the difficulty may not necessarily be due to a phonological impairment. Another possibility is that the children were unable to maintain the sound of the phoneme in their short term memory (McBride-Chang, 1995) at the same time as retrieving suitable words.

Snowling (2008) suggested that some children with dyslexia may have 'oral language difficulties' and, although the children with CP generally had typical scores on the CCC2 communication test and often typical levels of language ability (see Chapter 3), some of them appear to have had difficulties perceiving or manipulating individual sounds in speech. Studies of phonological awareness in children with CP (Bishop and Robson, 1989; Card and Dodd, 2006) all reported that the children had lower scores on phonological processing tests than their typically developing controls. Where the children with CP had severe speech and language problems, researchers (Dahlgren Sandberg and Hjelmquist,



1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008; Vandervelden and Siegel, 1999; 2001) concluded that the children's problems with phonemic manipulation was due to their articulation difficulties which delayed the children's phonological development. However, many of the children in this study (see Table 4.1), who generally have typical speech and language abilities, also had phonological processing difficulties which suggests that lack of articulation may not be the only cause of the children's problems with the phonemic segmentation tests. These findings are similar to those reported by Dorman (1985, 1987), in studies of young people with CP. The children had mostly typical speech and language abilities but had problems with phonological processing.

Another test which has links with phonological processing is the rapid naming test in which the children had to name images of common objects such as trees and boats. The children were asked to name all the images before the test, so this test was not about the retrieval of words from long term memory but, according to Wolf and Bowers (2009), about the speed of translating visual images into verbal output. Lervag and Hulme (2009) speculated that rapid naming predicted later literacy abilities because neural circuits involving object recognition were also involved in visual word recognition. Researchers have reported significant correlations between rapid automatized naming and literacy abilities (Snowling, 1987; Hatcher and Snowling, 2002; Lervag and Hulme, 2009) and there are indications that these relations are stronger when the stimuli are numbers and letters. In general, most of the children performed very poorly on this assessment and one explanation might be that this is attributable to mild motor difficulties slowing down the rate of the children's speech, resulting in poor percentile scores. This suggests that the RAN test, when given to children with CP, may be assessing other abilities beyond those involving word retrieval and phonological awareness.

The correlations between the children's percentile scores on these three tests were non-significant with the weakest correlations between verbal fluency and the other two test scores. This suggests that the three assessments were concerned with different aspects of phonological processing, or it could be that the extra demands of some of these tests, e.g. rapid naming, produced additional variation in the scores of these measures.

Thus, the majority of children in this sample had impaired phonological abilities, with only four or five children having percentile scores in the typical range. Many of the children had very low percentile scores which indicate severely impaired phonological abilities. These findings are similar to previous research involving children with CP with breath control problems (dysarthria) (Bishop and Robson, 1989; Bishop et al, 1990; Card and Dodd, 2006). The children involved had lower scores on phonological processing tests than typically developing controls. The findings are also similar to studies involving children with CP who have severe speech and language problems, (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larrsen and Dahlgren Sandberg, 2008; Vandervelden and Siegel, 1999; 2001). Thus this study adds to the knowledge of the phonological abilities of children with CP where the majority of the children had typical levels of communication abilities (see Chapter 3).

#### Were the children's phonological abilities related to their literacy abilities?

Phonological difficulties are often considered to delay the acquisition of sound/ letter correspondence, which affects the development of reading and spelling skills (Hulme and Snowling, 2009). Generally, the children who were the poorest readers and spellers in the study also had the poorest percentile scores of the three standardised assessments, suggesting that the children who had poor perception of speech sounds were similar in

some respects to children with dyslexia (Frith, 2002; Hatcher and Snowling, 2002; Hulme and Snowling, 2009). Overall, the children's phonemic segmentation task was most closely related to their literacy abilities.

The children's phonological processing test scores generally demonstrate that the better readers and spellers in the study also had better phonological knowledge which corresponds to findings by Dorman, 1987; Vandervelden and Siegal, 1999, 2001). These findings are to be expected given the literature on typical children (Caravolas et al, 2001; Apel, 2009). However, other researchers of children with CP (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larssen and Dahlgren Sandberg, 2008) suggest that the children's phonological abilities were superior to their reading and spelling abilities.

Table 4.4 shows the correlations between the phonological and literacy test scores. The phonemic segmentation test had significant and highly significant correlations particularly with three of the reading tests and the spelling test. The verbal fluency test had a significant relationship with the TVTC nonword reading test but the RAN test had no significant correlations with the literacy measures. It would usually be expected that different tests of phonological abilities would have similar and significant correlations with literacy abilities.

Looking at the phonemic segmentation test first: the results had the highest correlations with the literacy tests, particularly the nonsense passage and the Salford reading tests which had highly significant relationships. The children with more developed literacy skills in the study would need to use phonological strategies on unknown words and nonsense words, and knowledge of orthographic and morphological units should have helped to

increase their performance (Frith, 1985; Ehri, 2002; Apel, 2009). Correlations between the verbal fluency (alliteration) test and the literacy tests only showed one significant relationship with the TVTC nonwords test. This reading test relies on children reading nonwords using phonological, orthographic or whole-word decoding skills. The correlation between the verbal fluency test and the TVTC test may indicate that the fluency test requires some of the same skills: sensitivity to the sounds in words (Goswami, 1999; McBride-Chang, 1995; Hatcher and Snowling, 2002).

The RAN scores had much poorer relationships with the literacy test scores, mainly because some of the better readers scored poorly. The test is designed to tap into the skills of visual input/ verbal output processing (McBride-Chang, 1995) and would typically advantage better readers (Hulme and Snowling, 2009). Most of the children performed badly on this test in common with children with reading disabilities (Wolf and Bowers, 1999; Hulme and Snowling, 2009) and these results may reflect difficulties the children had with processing visual information. However, the inconsistency between the literacy abilities and the RAN scores of some of the better readers is difficult to explain but might be attributable to mild motor difficulties which are sufficient to add variation to the children's speed in serial naming.

#### **4.4.1: Conclusion**

Many of the children with CP had low percentile scores on the phonological assessments which replicate the findings of previous studies. Over half the sample had difficulties with these tests but some of the children's results were inconsistent across the three tests, and this inconsistency of individual performance is found in the research literature. The phonemic segmentation test showed a significant relationship between the reading and spelling tests, consistent with previous research that indicates its importance in predicting,

or correlating with, the development of literacy skills. However, the verbal fluency test and RAN tests had weaker associations with the reading and spelling tests and this may be because these tests involve other abilities besides phonological processing.

## **Chapter 5: Visual and Spatial Perception in children with CP**

### **5.1: Introduction**

This chapter focuses on the visual perception and visual spatial abilities of children with CP. Previous studies have examined whether visual or spatial perception difficulties cause difficulties with literacy development in children with CP, however, such studies tend to focus on one aspect of literacy such as handwriting (James and Gauthier, 2009) or reading (Dorman, 1987) or on visual perception itself. There is often a lack of quantitative data, and formal or standardised testing of visual perception may be absent or not described in sufficient detail in order to enable comparisons across studies. This study (Study 4) was therefore designed to address some of these issues, and visual and spatial perception test scores were compared with the literacy scores, detailed in Chapter 2.

Several aspects of visual and spatial processing, and its testing, are considered and presented in two sections. The first section will examine evidence in the literature that children with CP have difficulties with visual perception. In the second section there is a consideration of the relatively limited theoretical discussions and evidence indicating that a relationship between visual perception and literacy difficulties in these children may exist.

#### **5.1.1: Research into visual perception difficulties in CP**

Dolphin and Cruickshank (1951) carried out some of the first research into the visual perception difficulties of children with CP. They concluded that children with CP had problems with figure- background confusion in comparison to chronological age-matched controls of typical children. They also had difficulties remembering a shape such as a drawing or geometric diagram when it was shown against contrasting backgrounds (see Figure 5.1) such as wavy lines. This test is based on one developed by Werner and Strauss

(1941), which follows the principles of gestalt theory in that the parts of a picture make up the whole, but perceptual organisation may make us see the whole differently.

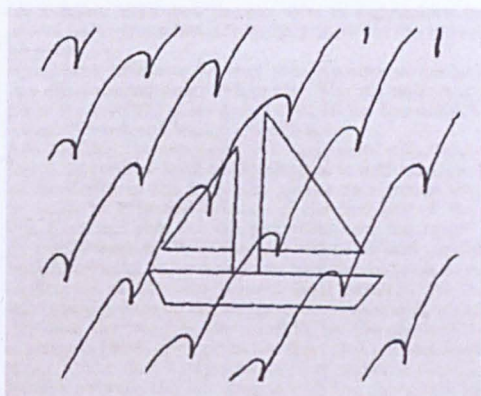


Figure 5.1: Figure- ground test (Dolphin and Cruickshank, 1951, Pg 229)

In comparison to the control group, the children with CP had difficulties identifying just the figure (boat) or they identified the background instead, but generally they were unable to identify both the figure and the background. More recently, Gal and Linchevski (2010) reported that some children had problems identifying which is the figure and which is the ground in visual scenes. This could relate to the Abercrombie (1964) study, described in Chapter 1, where the participant with CP was able to visualise and reproduce parts of shapes but the figures had a poor spatial relationship to each other.

Tests were given to sixty-eight children with CP as part of a study to assess visual impairment in a population of ninety-six children with physical disabilities, (Stiers, Vanderkelen, Vanneste, Coene, De Rammelaere and Vandenbussche, 2002), which examined the recognition of objects where the forms were obscured. This is one of the few investigations to use a battery of tests involving visual perception. Eight tests from the L94 battery (Stiers, van der Hout, Haers, Vanderkelen, de Vries, van Nieuwenhuizen and Vandenbussche, 2001) were given, of which six were similar to tests on visual memory, form constancy and figure closure, and two were block tests involving matching and

construction. The findings indicate that all children within the CP group were impaired on at least two of the tests but there was no information given about which tests the CP group found most difficult. All of the ninety six participants found form constancy and figure closure tests the most difficult and the block tests were the easiest. This research contributes to the limited evidence that children with CP have visual and spatial perception deficits, which affect visual memory (Arp and Fagrad, 2005); poor figure closure perception (Menken, Cermak and Fisher, 1987); figure ground perception (Nagle and Campbell, 1998) and object recognition when there is disturbance, e.g. partial obscurity by other patterns (Stiers et al, 2002).

In the next section, a number of studies are discussed in order to explore whether there may be a relationship between visual and spatial processing difficulties and the development of literacy skills. There have been limited studies into connections between reading, spelling and phonology in children with CP and visual processing, but a larger number concerning handwriting or copying skills.

#### **5.1.2: Visual perception and its relationship with literacy in children with CP**

The earliest research on children with CP concerning visual perception was often based on children with neurological impairments, including CP, in comparison to typical children (Werner and Strauss, 1941; Dolphin and Cruickshank, 1951; Frostig, Lefever and Whittlesey, 1961). This research suggested that children with CP had difficulties with visual perception. The extension of Frostig's research (Maslow, Frostig, Lefever and Whittlesey, 1964) identified five areas where impairments of visual processing could affect literacy abilities: visual perception which they identified as necessary for learning processes; figure-ground perception for the ability to recognise words; form constancy to remember a word produced in different fonts and sizes and in different contexts; and spatial relationships for the order of letters in words and their position in space when writing.



Two studies mentioned in Chapter 1, concerned children and young people with CP and the relationship of visual processing to literacy abilities (Dorman, 1987; Dahlgren Sandberg and Hjelmquist, 1997). In the former study, thirty one adolescents with CP were tested on verbal, perceptual and intellectual measures to ascertain the relationship between these and reading. Despite most of the adolescents having quite severe impairments in visuospatial organisation (indicated by the Luria-Nebraska test) their reading (decoding and comprehension) abilities were closely related to their verbal and auditory skills. The latter study (Dahlgren Sandberg et al, 1997) concerned twenty seven non-verbal children with CP. The CP group scored significantly lower on the visual sequential memory test in comparison to two control groups with speech; one matched for mental age, and one for mental and chronological age. Differences were also reported between the readers and non-readers within the CP group indicating that the non-readers had much lower scores on the visual sequential memory test; however the difference was not statistically significant. Thus both studies failed to show significant relationships between visual processing and literacy but in both cases only one test of visual perception was used.

A relatively large body of research concerning visual perception in children with CP focuses on their handwriting and/ or copying abilities. Children with CP often have difficulties with copying or reproducing what they have been shown (Abercrombie, 1964). These difficulties may severely affect the children's development of handwriting skills. One might assume that the child's visual perception may be affecting their literacy development, however, the results of the copying task, reported in Chapter 2, suggest another influence, i.e. their motor difficulties with reproducing information rather than their visual perception abilities. Related to this, some researchers suggest that children with CP may have a constructional disorder, and that there needs to be a distinction made between the

children's visual perception and visual-motor abilities (Abercrombie, 1964; Koeda et al, 1997; Straub and Obrzut, 2009). Husain (2002) reported that, after damage to the parietal area of the brain; patients (not with CP) often exhibit visual-spatial impairments due to their inability to copy a drawing or to construct a three-dimensional object. Husain suggested that this is due to a visual impairment affecting the spatial awareness needed to detect the relationship between designs and objects, thus linking the relationship between the visual and physical aspects of reproducing an image. Husain's view is supported by Vidyasagar and Pammer (2010) who suggest in their review that problems with 'binding', where images are not perceived in their entirety, will affect a child's literacy development.

Visual sequential memory has been suggested as the most significant predictor in the fluency of handwriting. The three most significant predictors of handwriting speed were age, visual sequential memory and visual-motor integration, (Tseng and Murray (1994) and Tseng and Chow (2000). Aylward's (2002) review of children with very low birth weights found that these children also had visual perception, visual sequential memory and visual motor difficulties, despite typical abilities, in comparison to controls, which affected their abilities in reading, spelling and writing. Many children with CP have low birth weights and this may be a co-occurrent cause of developmental delay (Centres for Disease Control and Prevention, 2013). Thus, there is evidence that difficulties with visual sequential memory and visual-motor skills might affect the development of writing.

In summary: there have been a limited number of studies on the relationship between visual and spatial perception and literacy in children with CP. The studies above report that children with CP have aspects of visual and spatial difficulties but there appear to be limited visual tests in the studies, and correlations between the visual scores and literacy abilities appear to be inconsistent between studies. Usually, children with CP have been

found to have impaired visual perception but there has not yet been a systematic examination of the relationship between visual perception and literacy in children with CP. For this reason a comprehensive test of visual and spatial perception was administered to children with CP and the correlations between the subscales were examined.

### **Section 5.2: Study 4: Visual and spatial perception in children with CP**

This study has been designed to address some of the uncertainties surrounding the visual processing abilities in a group of children with CP who have variable literacy abilities.

#### **Questions**

**Do children with CP have visual and spatial perception difficulties?**

**Were the children's visual and spatial perception abilities related to their literacy abilities?**

#### **5.2.1: Method**

##### **Test of Visual-Perceptual Skills**

The Test of Visual-Perceptual Skills-3, TVPS-3 (Martin, 2006) is an assessment commonly used by occupational therapists in Britain. It can be utilised as a comparison to measure differences between a subject's visual perception skills where one or more skills may be impaired while other features are intact. It has been used in many research studies primarily those for testing visual perception in people with cerebral or ocular impairment (Kiper, Zesiger, Maeder, Deonna and Innocenti, 2002, and Khaw, Tidemann and Stern, 2008). It consists of seven sections of fifteen plates which together assess the skills needed to be able to visually perceive or interpret what is seen or observed: Each individual test can be used to provide age-equivalent scores and percentiles. The test also provides overall percentile scores and median visual-perception ages. The test is not timed and can be completed in one session or broken up into smaller sessions depending on the

concentration of the child. The series of pages are shown on a slanted surface and can be placed close to the child to make it easier for the child to touch selected items.

#### Test 5.1: Visual memory

This is the ability to remember, within a short space of time, the exact shape, form, number or object from others that are then shown to the children. The test consists of an image shown on one page for five seconds. The page is turned and the child has to choose the shape from four shapes illustrated. The shapes become more complex as the test continues. The ability to hold a shape or form in the memory is necessary when transferring images or words from one medium to another, e.g. copying from a board.

#### Test 2.2: Visual Sequential Memory

The test requires the child to remember a set of common geometric forms, e.g. circle, triangle, square, and then select the same grouping of shapes from a series of four. The process of visual sequential-memory involves the ability to remember a group of forms such as letters, words or sentences in a specific sequence and is necessary when learning to spell and read.

#### Test 5.3: Visual Spatial Relationships

The test requires a child to look at a series of five shapes on a page. One of the shapes is slightly different, e.g. it may be facing the opposite way. The child has to identify the odd one out. Visual spatial-relationship involves the ability to understand the relationship between the positioning of shapes or objects. Difficulties with the perception of spatial relationships may affect writing skills such as the placement of words on lines or spaces between words. There may also be difficulties with the concepts of placement such as 'up', 'down', 'right' and 'left'.

#### Test 5.4: Visual Discrimination

The test requires a child to match a shape at the top of a page with one of the five shapes at the bottom of a page. Visual discrimination is the ability to distinguish between similar

or dissimilar shapes, colours, patterns, forms, and their positioning. Difficulties with visual discrimination can affect the ability to identify similarities or differences between letter shapes, words, and images which result in problems with learning numbers and letters, and word recognition.

#### Test 5.5: Visual Form Constancy

A shape is displayed in the top half of the page. In the bottom half, five images are displayed in which the first shape has been rotated or disguised in some way within one of the images. Visual form-constancy is the ability to recognise, remember or name shapes, objects and forms by their particular characteristics. Difficulties with this ability will cause problems with remembering spellings or words when they are presented in a different context e.g. a word on one page of a reading book will not be recognised on the next page, or a word that is written in one context will not be remembered at another time.

#### Test 5.6: Visual Figure Ground

Visual figure-ground is the ability to perceive an image which is hidden in some way against a background. The test requires a child to look at a shape at the top of a page. Underneath are four diagrams, one of which has the exact shape embedded within other patterns. Difficulties with the ability to discriminate shapes that are within a number of other shapes may affect reading skills such as picking out or identifying words within text on a page.

#### Test 5.7: Visual Figure Closure

Visual closure is the ability to identify or fill in, mentally, an incomplete image, such as described by gestalt theory (Goldstein, 1999) and allows us to make sense of our world. The test requires a child to look at an incomplete image and identify the completed form from four images on the same page.

### Amalgamation of Scores: Visual Perception

When the seven tests are completed and scored, an overall percentile score can be calculated. Percentile scores above 24 are shown in coloured cells in table 5.1. The children have been ranked in the table as previously, with the more able readers at the top.

### 5.3: Results

Table 5.1 shows that almost all of the children had difficulty with the visual perception tests with only one child, Joe, scoring in the typical or above typical range in every category.

Table 5.1: Visual and spatial perception percentile scores and descriptive statistics

	Vis mem	Vis seq mem	Spat rel	Vis disc	Form con	Fig ground	Fig clos	Total VP
Ian	0	37	50	2	0	2	0	3
Lewis	2	37	25	5	0	0	2	4
Beth	1	47	1	1	1	8	3	2
Garth	50	25	95	9	2	5	5	19
Joe	27	55	66	79	32	82	88	68
Harry	0	0	0	0	0	0	0	0
Emma	55	12	73	5	10	27	1	7
Cleo	1	9	9	2	5	9	1	18
Linda	1	8	1	1	4	53	1	1
Amy	0	0	0	0	0	1	16	0
Chris	9	25	2	1	0	0	0	1
Rob	1	1	1	1	1	1	1	0.1
Lee	1	1	1	1	14	8	1	6
Jon	2	9	5	5	0	25	0	3
Will	0	0	0	1	0	0	16	0
Mean	10	17.7	21.9	7.53	4.6	14.73	9	8.8
SD	18.61	18.86	32.4	19.92	8.66	23.71	22.5	17.47
Numbers of typical scores	3	6	5	1	1	4	1	1

Most of the other children scored very poorly on most tests but had a typical score in one or two of them. The visual discrimination task, the form constancy task and the figure closure tasks were the assessments that most of the children found difficult, while the

more able readers usually had typical scores on the assessments for spatial relationships and visual sequential memory.

Looking at the descriptive statistics in Table 5.1, Joe's scores have skewed the results slightly and made the means scores higher than would be the case otherwise; however, all of the mean percentile scores are below the typical level.

The form constancy test had the lowest score overall with the smallest standard deviation showing the difficulty all of the children had with this test. The tests for visual spatial relationships, figure ground and visual sequential memory all had mean scores between 14.73 and 21.9, with between 4 and 6 children scoring in the typical range. The test that had the most typical scores was visual sequential memory, and it was notable that generally the better scores came from the better readers (the first five children in Table 5.1).

Table 5.2: Correlations between the visual and spatial percentile scores

	visual memory	visual sequent memory	visual spatial relations	Visual discrim	Visual form constancy	Visual figure ground	visual figure closure
visual memory	x	x	x	x	x	x	x
v sequential memory	<b>0.57*</b>	x	x	x	x	x	x
v spatial relationships	<b>0.76**</b>	<b>0.74**</b>	x	x	x	x	x
visual discrimination	<b>0.74**</b>	<b>0.69**</b>	<b>0.92**</b>	x	x	x	x
v form constancy	0.47	0.23	0.39	0.38	x	x	x
v figure ground	0.43	0.32	0.44	0.49	<b>0.76**</b>	x	x
v figure closure	0.08	0.1	0.002	0.17	0.3	0.11	x
visual perception	<b>0.71**</b>	<b>0.65**</b>	<b>0.87**</b>	<b>0.86**</b>	<b>0.68**</b>	<b>0.61*</b>	0.16

\* Correlation is significant at the 0.05 level (2-tailed)

\*\* Correlation is significant at the 0.01 level (2-tailed)

Table 5.2 shows that most of the sub-tests had moderate or strong correlations with one another, and a number of these were significant, particularly the following: visual memory,

visual sequential memory, visual spatial relationships and visual discrimination. The visual perception test summary scores had significant correlations with all the tests except one. The form constancy, figure ground and figure closure tests all had much weaker relationships with each other and the other tests except for the visual perception test.

Table 5.3 shows the correlations between the literacy score from Chapter 2 and the visual assessments. The visual sequential memory test has the highest number of significant correlations with the literacy tests, while the spatial relationships test also has moderate and one significant correlation with the reading tests. The visual discrimination and the

Table 5.3: Correlations between percentile scores of literacy and visual/spatial tests

	V Memory	V Seq Memory	V Spatial Rel	V Discrimination
One minute reading	0.07	<b>0.63*</b>	0.47	0.36
Nonsense word passage	0.2	<b>0.67**</b>	<b>0.52*</b>	0.33
Salford Reading Test	0.1	<b>0.67**</b>	0.48	0.43
TVTC Nonword Test	0.1	<b>0.62*</b>	0.26	0.17
Two minute spelling	0.11	<b>0.63*</b>	0.37	0.33
One minute writing	0.12	0.33	0.11	0.21
	V Form Constancy	V Fig Ground	V Fig Closure	V Perception Total
One minute reading	0.004	-0.06	0.18	0.35
Nonsense word passage	-0.07	-0.14	0.09	0.33
Salford Reading Test	-0.22	-0.15	-0.004	0.36
TVTC Nonword test	0.07	-0.19	-0.09	0.13
Two minute spelling	-0.32	-0.18	-0.2	0.16
One minute writing	0.21	0.32	0.12	0.3

\* Correlation is significant at the 0.05 level (2-tailed)

\*\* Correlation is significant at the 0.01 level (2-tailed)

visual perception tests showed weaker correlations with all the literacy measures. The three visual measures that had the weakest relationship with the literacy measures were the visual memory, the form constancy and the figure closure test results.



## 5.4: Discussion

### 1. Do children with CP have difficulties with visual and spatial perception?

The overall scores from the majority of the tests show that, in common with other researchers' findings (Dolphin and Cruickshank, 1951; Frostig et al, 1961; Maslow et al, 1964; Abercrombie, 1964; Dorman, 1987; Stiers et al, 2002; Arp and Fagard, 2005; Straub and Obrzut, 2009), children with CP have severe difficulties with visual and spatial perception. For the majority of the visual tests the children had percentile scores below 25, and often below 5. This indicates severe visual perception difficulties. Even the children with typical or near typical literacy abilities had low percentile scores on the following tests: visual discrimination, form constancy, figure ground, and figure closure. This suggests the visual abilities assessed by these tests were not contributing to the children's literacy abilities.

However, there were important exceptions to this pattern. Most of the children with typical or near-typical literacy abilities also had percentile scores in the typical range for the visual sequential memory test and the spatial relationships test, and some had typical scores on the visual memory test. Therefore it would appear that visual sequential memory, spatial relationships and possibly visual memory might be necessary for the typical development of literacy abilities in children with CP.

Inter-correlations between the visual perception test results show significant and highly significant correlations between visual memory, visual sequential memory and visual spatial relationships suggesting that all three tests use or tap into similar visual skills. This is to be expected as the test was designed to assess related visual perception abilities and provide an overall score of visual processing ability. However, form constancy, figure ground and figure closure had weak correlations with the three previous tests, but several

of the correlations between figure ground with the other two tests were above .4 and there was one highly significant correlation with form constancy. Visual figure closure had the weakest relationship with all the other tests. One limitation that should be noted when interpreting these findings is that for those assessments which produced very low scores, the correlations between different assessments may have been reduced because a number of children had the same score.

Thus the children with CP in this sample have severe difficulties with visual and spatial perception although on a day to day basis one might not notice these difficulties. Only some of the children had scores in the typical range, and so an important question is whether there were links between visual and spatial perception abilities and literacy, and this issue is considered in the next section.

## 2. Were the children's visual and spatial perception abilities related to their literacy abilities?

In this section there is a further examination of whether there was a relationship between the children's visual test results and their literacy abilities in terms of the correlations between these domains. The prediction was that the children who had better visual perception abilities were more likely to have higher literacy scores. However, the findings of this study have shown that this is not always the case. In four of the tests: visual discrimination, form constancy, figure closure and total visual perception, all of the children (apart from Joe) had scores well below typical levels. There were weak correlations between the four tests and the reading and spelling tests which differ from the findings of previous research (Frostig et al, 1961; Maslow et al, 1964). Low test scores, particularly those at floor levels on both visual and literacy tests, might have affected the detection of significant correlations and this is discussed below.

Some findings from this study did not follow expectations that the better readers would have higher visual and spatial scores. Figure closure is a measure where forms are incompletely drawn, and the completed form has to be selected from a choice of four. Problems with completing this test might be due to difficulties with 'feature binding' (Husain, 2002; Bays, Wu and Husain, 2011) where impairments in the parietal system cause forms to be incoherently or simultaneously perceived which can affect working memory.

Figure ground difficulties were one of the key areas to be identified in early research in children with neurological impairment including CP (Werner and Strauss, 1941). Further, difficulties with figure ground perception have been linked to learning development (Dolphin and Cruickshank, 1951) and literacy development (Frostig et al, 1961; Maslow et al, 1964). Later research (Nagle and Campbell, 1998; Katoch, Devi and Kulkarni, 2007) supported the claims that that figure ground perception difficulties might cause problems with perceiving print on the page and impede word recognition. However, up to now, there has been no direct examination of the relationship between figure-ground performance and literacy. The findings from this study show that, although many of the children had problems with this test, the better readers had some of the worst results of between 0 and the 8<sup>th</sup> centile while some of the less able readers had typical scores, and there were low correlations between the test and literacy performance.

Difficulties with form constancy have been identified as causing problems with word recognition in different investigations: in children with CP (Frostig et al, 1961; Maslow et al, 1964); and in children with dyslexia (Valdois, Bosse and Tainturier, 2004). Again, the expectation was that the children with higher form constancy scores would have higher literacy scores, but the better readers had some of the lowest scores: between 0 and the

2nd centile. There were almost zero correlations between the figure closure measures and literacy scores which is a surprising result as, generally, better readers such as those in the consolidated phase (Ehri, 2002) will skim over known words on a line and be able to read without giving minute attention to every individual word.

The difficulties may be because the test forms are not within a literacy context but have more affinity with geometric shapes (Gal and Linchevski, 2010) and the visual organisation required or with subtilizing (Arp and Fagard, 2005) where there is an inability in children with CP to perceive visual scenes. Interestingly, this test has a similar format to the Raven's test and so poor visual and spatial perception abilities might be an explanation of the children's poor performance on the form constancy test (see Chapter 3 and Appendix 5: Correlations between cognitive test scores). Pueyo et al (2008) did not use a test for form constancy in their study on the RCPM in comparison to other cognitive abilities, but their findings show that visual memory and visual perception, along with receptive vocabulary, were the best predictors of RCPM in children with CP.

Previous research has linked visual sequential memory to handwriting ability (Feder et al, 2005; Tseng and Murray, 1994; Tseng and Chow, 2000). ARP and Fagard (2005) and Gal and Linchevski (2010) linked low scores in visual tests with difficulties with gestalt perception and the perception and memorising of visual information such as in handwriting. James and Gauthier (2009) discuss the effects of proprioception where a poor sense of the body and its actions, coupled together with poor visual perception, will affect the ability to learn information involving both sensory processes. However, although the Tseng studies showed relationships between visual sequential memory and handwriting, this has not been borne out by the results of this study. There were only some weak non-significant

correlations between five of the visual tests and handwriting, but this may be a reflection of the low scores on all the tests.

The better readers scored well in two areas: visual spatial relations and visual sequential memory, and these tests had a highly significantly correlation with literacy abilities. The visual spatial relationships test assess the abilities of the child to recognise a given shape within other shapes, which could explain why the better readers were able to complete this test successfully as it may correspond with their abilities to distinguish words within a line of words. The fact that the spatial relationships test scores correlated with the children's abilities in visual sequential memory, can explain why the children are able to remember sequences of information, for example letters or orthographic sections of words. It is of relevance that, according to a review completed by Vidyasagar and Pammer (2010), children with dyslexia have difficulties with learning phoneme/ grapheme correspondences, which they suggest may be due to having an impaired visual system linking into an impaired aural system, particularly concerning 'spatial sequencing' (Pg 1).

It is also useful to consider the findings concerning spelling. In children with dyslexia, one of the main causes is considered to be an impairment in phonological processing (Snowling, 1987; 2008; Frith, 2002; Ehri, 2002, 2005; Hatcher and Snowling, 2005; Vellutino and Fletcher, 2005; Apel, 2009), and investigations into children with CP have provided similar results (Bishop and Robson, 1989; Bishop et al, 1990; Dahlgren Sandberg and Hjelmquist, 1997). However, a question arises as to whether developmental delay in spelling abilities, such as learning grapheme/ phoneme correspondence, are caused by visual perception difficulties because the child is unable to process or reproduce the written form of the word.

There was a significant correlation of 0.52 between the visual sequential memory scores and those of the two-minute spelling test, and this reflects the results shown in Dahlgren Sandberg's longitudinal study (2001). The two best readers were also the best spellers and both had typical scores, but there were inconsistencies as Joe had the best visual sequential score of 55 but only a spelling percentile of 9, while Harry had a spelling percentile of 25 but scored 0 on the visual test. This suggests that Harry used aural/phonological strategies to spell, while Joe may have relied on visual /phonological strategies in the assessments. Children who have the same surface reading skills may use different strategies in decoding and spelling, and this will have implications for pedagogy. Lassus-Sangosse, N'guyen-Morel and Valdois (2008) compared groups of children with dyslexia and reported that the better the children are at remembering letter strings, the better they are at reading, however Joe is different in that he has typical abilities at remembering sequential information but has very poor reading abilities.

In summary, these findings suggest that visual sequential memory could be an important ability which influences the children's literacy abilities, as the correlations between this test and the literacy tests were very strong. The other visual test which had moderate to strong relationships with the literacy measures was visual spatial relationships, which suggests it could be a less important influence. Please see Table A5.1 in Appendix 5 to see further information regarding the test scores of visual sequential memory and spatial relationships, and their relationship with the other cognitive measures.

#### **5.4.1: Conclusion**

This chapter set out to investigate the visual and spatial perception abilities of a group of children with CP. Previous research indicated that children with CP have poor visual-spatial perception skills which can affect their ability to develop literacy skills. The study was

designed to examine whether children with CP had poor visual and spatial processing abilities, and whether or not these abilities related to their literacy abilities.

The following conclusions were made:

1. The majority of the children had very poor visual-spatial perception skills.
2. The children who were the better readers and spellers had better results in two visual tests: visual sequential memory and visual spatial relationships, and it is possible that these two forms of visual perception are necessary for typical literacy development.

The next chapter will examine working memory processes in children with CP in order to ascertain whether there is a relationship between the children's literacy abilities and their working memory abilities.

## **Chapter 6: Working memory and children with CP**

### **6.1: Introduction**

In previous chapters, reference has been made to children with CP having difficulties with working memory (Jenks et al, 2007; Larsson and Dahlgren Sandberg, 2008; Peeters et al, 2009a). This chapter is going to examine the working memory system of the children described in Chapter 2 in order to establish whether these children also have working memory difficulties and if so whether they are across all the components of the system or located within one of the subsystems. The aim is also to discover whether there is a relationship between the subsystems of working memory and literacy difficulties, as has been reported in children with literacy impairments (Gooch, Snowling and Hulme, 2011; Henry, 2012; Bacon, Parmentier and Barr, 2013).

In the next section, investigations into the ability of children with CP in relation to the three main subsystems of working memory will be outlined, using terminology derived from Henry (2012): phonological short term memory (PSTM), visual short term memory (VSTM) and executive loaded working memory (ELWM).

#### **6.1.1: Phonological short term memory (PSTM)**

Research into children with CP, both with and without communication difficulties (Carlsson, 1997; Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Jenks et al, 2007; Larsson and Dahlgren Sandberg, 2008; Peeters et al, 2008; Peeters et al, 2009; Pueyo et al, 2009) has focused on PSTM measures. However, because many of the children with CP had communication difficulties, changes were made to the tests which may have altered the nature of those tests. This section describes research into PSTM in children with CP and whether the results are different between children who can verbally communicate and



those that have speech and language difficulties, a topic which was often the focus of previous research.

PSTM tests consist of recall tests where participants are asked to recite back a list of words or digits, but children with CP and communication difficulties are unable to verbally give answers so measures in the following studies were adapted, e.g. in the verbal recall task, words or digits were presented visually for identification (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008). This raises the question of whether these are, strictly speaking, PSTM tests as both verbal and visual cues are given, and attention is switched between both subsystems. Generally the children with CP had poorer results in the working memory tests than the mental-aged matched comparison groups (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008).

Two studies (Peeters et al, 2008; Peeters et al, 2009a) of Dutch children with physical disabilities contained a large number of children with CP (54; 52 respectively) who had varied communication abilities. In both studies word list matching tests were used, amongst a battery of other tests, where two strings of words are repeated and the children had to identify whether the strings matched. This test does not require verbal report so a lack of speech does not affect the outcome. In both studies the children with CP had poor results with mean results of 14.61 and 21.94 respectively (comparison group: 32.18). Further analyses of the data suggested that the children's IQ measure (Raven's Matrices) strongly correlated with the working memory abilities of the children with CP.

Only one study (Peeters et al, 2008) contained word recall and nonword recall tests where the majority (84%) of the children with CP had understandable speech and comparison

groups were matched for mental age. Results of the tests were compared with tests of intelligence, auditory perception and speech abilities. In both of the memory tests, Peeters et al (2008; 2009a) found that the children with better speech abilities and intellectual abilities had better PSTM standard scores. A forward digit test was also used in a study on children with CP, where no comparison groups were included (Pueyo et al, 2009). The results indicated that just over half of the children were impaired in PSTM.

Thus, researchers have identified that children with CP have difficulties with phonological short term memory in comparison to typical children of similar mental abilities. However, researchers when testing children with CP who have speech and language difficulties may alter test conditions, and this might affect the children's results. The children would have been asked to indicate their answers by pointing or by their use of communication devices, both of which may have resulted in a delay in answering.

Studies into word length effect are relevant to this issue. The phonological store is theorised to hold information for about two seconds (Baddeley, 2007) so it will be more difficult to hold longer pieces of information and keep them intact in the memory. Children with CP often have slower speech or process speech more slowly (Peeters et al, 2009a) which might affect the amount of information or words they can rehearse in PSTM without causing overload. However, a study by White, Craft, Hale and Park (1994) on twelve children with spastic diplegic CP found that although the children's articulation rate was slower than their peers, their memory spans for recalling one, two and three-syllable words were similar to the thirty-eight age-matched and IQ-matched controls. This suggests that retention of information in the short term phonological store was unaffected by articulation difficulties, and retention in both groups may have been due to acoustic rehearsal.

A limited number of researchers have investigated relationships between PSTM systems and phonology, spelling and reading (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008). The studies focused on whether lack of speech resulted in difficulties with the children's PSTM and, consequently, their literacy development. Dahlgren Sandberg and Hjelmquist, (1997) concluded that there was a relationship between the children's difficulties with non-verbal phonological processing and their difficulties with phonological short-term memory. A comparison between good readers and non-readers in the CP group (Dahlgren Sandberg and Hjelmquist, 1997) revealed that the good readers had higher scores in the digit recall test than the non-readers which suggests an association between the children's abilities in PSTM and their reading development. These results indicate that children with CP, who have good communication abilities, are more likely to have better PSTM than children with CP who have poor communication abilities (Dahlgren Sandberg and Hjelmquist, 1997; Peeters et al, 2008). However, given the lack of research comparing PSTM with literacy development in children with CP, Study 5 aimed to provide new information about this topic.

### **6.1.2: Visual short term memory (VSTM)**

Several studies have utilised VSTM measures as part of a battery of tests when assessing children with CP. The most common test used was the Corsi blocks test (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008; Pueyo et al, 2009) or a version of the test on a computer to make it more accessible for children with CP (Jenks et al, 2007). In four of the studies, the CP group performed less well than chronological or mental-aged comparison groups (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Jenks et al, 2007; Larsson and Dahlgren Sandberg, 2008) suggesting that children with CP often have impaired VSTM. This was also

indicated by the findings of a study by Pueyo (2009) who reported that 29% of the children with CP had low scores on the block test using normative data as a comparison.

One of the studies (Dahlgren Sandberg and Hjelmquist, 1997), which looked into language and literacy of non-vocal children with CP compared the results of the Corsi blocks task with good readers and non-readers within the CP group. The good readers were found to have significantly higher scores on the Corsi block test than the poorer readers. While the authors acknowledged that the more able readers had better visual memory abilities, analysis of the data did not indicate a significant relationship between the literacy difficulties of the poorer readers and their VSTM results.

Another researcher looked at a different aspect of visual working memory: memory for drawings and spoken words in hemiplegic children with CP (Carlsson, 1997). The children with CP and left-side impairments took longer to learn the drawings in comparison to a word-learning task; in contrast, the children with right-side impairments took the same length of time for the drawings and words. Carlsson suggests that children with left-side hemiplegia have more difficulty with visual perception and that this impeded the learning of the visual task. This raises the question of whether children with certain types of CP may have more difficulty with learning because of the location of the brain impairment.

### **6.1.3: Executive Loaded Working Memory (ELWM)**

While there have been a number of studies on the subsystems of working memory, there are very few studies about ELWM. Only three studies, to date, appear to involve assessments which include the central executive as well as verbal or nonverbal recall tests in children with CP. All three studies (Jenks et al, 2007; Larsson and Dahlgren Sandberg, 2008; Pueyo et al, 2009) contain backward digit tests, and the latter two studies also

contain backward Corsi tests. There were differences in the findings of the studies and also the use of different comparison groups (Jenks et al; Larsson et al) or none at all (Pueyo et al).

In two of the studies, children with CP had poor performance on the ELWT test in comparison to standardised scores (Jenks et al, 2007; Pueyo et al, 2009), however, in the other study (Larsson and Dahlgren Sandberg, 2008), the children with CP were much better at backward digit than their mental-age matched comparison group. Because the ages of the controls, in the latter study, were much lower than the CP group (5.6 years and 8.7 years respectively) this may account for the differences between the groups. The authors acknowledged there were difficulties with interpreting the results of the CP group in some of the tests, and the immaturity of the control group may have affected their abilities with identifying or manipulating numbers. There were also differing results between the two studies that contained backward Corsi block tests. Only 21% of children with CP had problems with the test in one study (Pueyo et al, 2009) while the CP group in the other study performed worse than the comparison group (Larsson and Dahlgren Sandberg, 2008).

In conclusion, children with CP have been investigated to establish whether they have working memory difficulties. In the majority of studies the children have been found to have phonological short term memory difficulties but some studies have also pointed to problems with visual short term memory. Studies into the subsystems of ELWM and its relationship to literacy in children with CP are severely lacking, particularly in children with typical communication abilities. To address this, Study 5 was undertaken and children with CP were tested on a number of standardised working memory tests in order to answer the following questions:

### Do children with CP have difficulties with the working memory system?

The majority of the working memory tests on children with CP have shown that many of the children have problems with working memory systems. However many of these children had impairments with communication and may have found it difficult to express their answers. The children in this study have more typical communication abilities and may be expected to have more typical PSTM; however their poor visual perception abilities (see Chapter 6) suggest that they may have more difficulties with VSTM. Thus, it is difficult to predict whether the children's visual difficulties will affect their performance on the tests for ELWM.

### Are the children's working memory abilities related to their literacy abilities?

Studies into working memory have predicted that PSTM skills are associated with literacy skills (Savage, Lavers and Pillay, 2007), while other studies have linked VSTM with the development of handwriting skills in DCD (Alloway and Temple, 2007). It might be predicted that the children with CP, who have better PSTM, will have better reading and spelling skills, while the scores of the VSTM tests may have a relationship with their handwriting skills. It is also likely that the better readers will have higher scores in the ELWM assessments.

## **6.2: Study 5: working memory in children with CP**

### **6.2.1: Method**

All the assessments were taken from The Working Memory Test Battery for Children (WMTB-C) (Pickering and Gathercole, 2001) except that the backward digit test from the DST (Fawcett and Nicolson, 2004) was employed.

The tests are divided into three aspects of working memory:

- PSTM: Verbal tests for the phonological loop short term memory aspect of working memory
- VSTM: Non-verbal tests to test the visual spatial sketchpad (VSSP):
- ELWM: Manipulation of data to test the central executive.

The tests in the WMTB-C consist of a number of trials which progressively get more difficult. Each set of trials consist of six tests. If the child correctly completes the first four trials in each block, then the next set of trials is started. However, if the child gets three errors in a block then the test is stopped. The number of correct scores is converted into a percentile score. The word list matching test, (Pickering and Gathercole, 2001) is part of the group of subtests within the PSTM. However, it is often considered to be more in line with tests examining short term memory in the central executive (Savage et al, 2009; Henry, 2010), as it is more complex than the other verbal recall tests (Hulme and Snowling, 2009). Therefore the word list matching test was included within the tests for ELWM.

### Verbal Tests: Phonological loop or PSTM

#### Test 6.1: Digit Recall

Digits are orally presented to the child who is expected to repeat them correctly and in order. The first block consists of single digits while the last block consists of sequences of nine digits.

#### Test 6.2: Word List Recall

This test is similar to the digit recall test except that single-syllable words are used in place of digits. The child has to recall not only the words, but the words have to be in the correct order. The first block consists of single words to be recalled, while the most difficult test consists of sequences of seven words.

### Test 6.3: Nonword List Recall

This test is similar to Test 1 and 3, except that nonwords are used. The nonwords are all single syllable words, some of which are simple cvc words while others have blends at the beginning or ends of words. As before, it is important that not only each nonword is correctly pronounced but that they are repeated in the correct sequence.

### Non-verbal Tests: Visual Spatial Sketchpad or VSTM

#### Test 6.4: Block Recall

A board of blocks, with no markings apparent to the child, although block numbers are visible to the tester, is used in this test. The tester taps a number of blocks in turn which have to be repeated by the child. The child has to tap the correct blocks in the correct sequence. The first set of trials consists of tapping a single block, while the most difficult set consists of nine blocks to be correctly tapped. For children with CP this task makes minimal demands on their motor skills.

#### Test 6.5: Mazes Memory

This test consists of mazes with previously marked routes to get from the outside to the middle using a specific route. The child is shown a maze which has been marked with a red pen. After three seconds the maze is covered up and the child has to reproduce the route on an empty maze. The first mazes are very small and simple but increase in complexity as the test continues. The need to reproduce the route makes higher demands on the children's motor control, so the children used a coloured felt-tip pen to mark the route or used a finger to indicate where a line should go.



## Manipulating Information: The Central Executive or ELWM

### Test 6.6: Listening Recall

In this test the child is given a series of short sentences, some of which are true (e.g. scissors cut paper) while others are false (e.g. balls are square). The child has to say whether each statement is true or false, and then repeat the last word of the statement (paper, square). In the first block the child is given one statement for each trial but in each consequent block of trials another statement is added. Thus, in the next block two statements are given at the same time, while in the next block three statements are presented. In the most difficult set of trials, six statements are presented. A score is given when the child correctly identifies whether the statement was true or not, and the correct last word is given.

### Test 6.7: Word List Matching

In this test the child is given word lists in pairs. Sometimes the words in each list are in the same order, while at other times the words in each list are in a different order. The child has to identify whether the word order is the 'same' or 'different'. The first block of trials contains lists of two words, while the most difficult trial contains lists of nine words.

### Test 6.8: Backward Digit Recall

This test (from the DST-J) consisted of series of numbers presented to the child which have to be reversed and repeated in the correct sequence. As this test was initially completed as part of the series of tests for Chapter 5, the WMTB-C was not administered, and the percentile scores from the DST-J were used in the analyses.

## **6.3: Results**

The percentile scores of the PSTM tests in Table 6.1 for digit, word and non-word recall show that most of the children had above average percentile scores on these assessments. In these three tests it was notable that some of the poorer readers (near the bottom of the

table) had very high scores with some percentile scores above 75. The mean percentile scores of the three recall tests are above fifty, with between ten and thirteen children scoring at typical or above typical levels of short term phonological memory. There was a wide standard deviation on all three tests reflecting the high abilities of many of the children in these tests in comparison to some of the zero scores of others.

Table 6.1: Percentile scores from the Working Memory tests (Coloured cells indicate typical scores)

Name	Digit Recall	Word List Recall	Nonword List Recall	Block Recall	Mazes memory	Listen Recall	Word List Matching	Backward Digit
Ian	71	100	100	0	0	19	16	60
Lewis	69	99	100	0	0	96	55	91
Beth	62	57	89	0	0	0	25	30
Garth	100	97	36	1	13	24	88	45
Joe	85	99	89	42	3	71	78	50
Harry	6	61	0	0	0	0	0	50
Emma	47	50	65	0	0	98	2	15
Cleo	77	91	78	5	5	2	30	4
Linda	22	25	23	0	0	8	25	2
Amy	94	57	29	0	0	1	0	10
Chris	69	91	89	16	0	24	2	4
Rob	20	11	4	3	0	0	11	20
Lee	55	97	94	0	0	0	0	35
Jon	0	7	0	53	2	18	0	10
Will	0	53	0	4	0	1	0	30
Mean	51.8	66.33	55.2	8.27	1.53	24.13	22.13	30.4
SD	34.12	33.06	38.65	16.6	3.5	34.88	29.33	25.26
No of Typical scores	10	13	10	2	0	3	6	8

In contrast almost all of the children had percentile scores in the atypical range in the VSTM tests (below the 25<sup>th</sup> centile) with the mean scores for the group being below ten: only two children scored within the typical range in the block recall task, and only one of those was in the better readers' group. It is notable that the top three readers had percentile scores of zero in this test. Similarly the top three readers had percentile scores of zero in the

Memory Mazes test where none of the children scored above the 13<sup>th</sup> centile and eleven out of the fifteen children again received percentile scores of zero. While the standard deviations were very wide in the PSTM tests, the standard deviation of the mazes test was only 3.5.

There were three tests to measure central executive skills: Listening recall test; word list matching test; and the backward digit test. The better readers scored more highly in these tests, particularly in the word list matching and the backward digit tests. The listening recall test was the most problematic for the majority of the children, however three of the better readers scored well in this test with two scoring above the 90th centile. The mean scores of the whole group on the three ELWM tests ranged between 22.13 and 30.4 whereas the mean scores of the PSTM tests were above fifty, and those of the VSTM tests were below ten. The standard deviations of the ELWM were similar to those of the PSTM reflecting the percentile scores of zero scored by some children in comparison to the very high scores achieved by others.

As can be seen in Table 6.2, the three verbal recall tests, relating to PSTM, had significant or highly significant correlations with each other as might be expected. The digit and word recall tests also had high or significant correlations with the word list matching and backward digit tests of the ELWM.

There was a significant correlation between the block recall and the mazes memory tests suggesting that these were measuring the same type of visual and cognitive processes. However, correlations involving the block recall and the mazes memory test need to be treated with caution as so many of the children had percentile scores of zero.

Table 6.2: Correlations between working memory scores

	Digit recall	Word recall	Nonword recall	Block recall	Mazes Memory	Listening recall	Word list match	Back digit
Digit recall	x	<b>0.679**</b>	0.513	-0.042	0.418	0.367	<b>0.598*</b>	0.161
Word recall	x	x	<b>0.790**</b>	-0.132	0.184	0.322	0.459	<b>0.657**</b>
Nonword recall	x	x	x	-0.202	-0.088	0.357	0.410	0.434
Block recall	x	x	x	x	<b>0.621*</b>	0.104	0.082	-0.275
Mazes memory	x	x	x	x	x	0.299	0.500	-0.030
Listening recall	x	x	x	x	x	x	0.471	0.110
Word list match recall	x	x	x	x	x	x	x	0.227
Backward digit	x	x	x	x	x	x	x	x

\* Correlation is significant at the 0.05 level (2-tailed)

\*\*Correlation is significant at the 0.01 level (2 tailed)

The three central executive tests were not significantly related with one another, but showed weak to moderate associations with some of the other tests: the listening recall test with the word matching test, and the backward digit test with the word recall test. The word list matching test had a larger number of moderate associations with the other tests: involving word recall, nonword recall, listening recall (rho above 0.4), and the mazes test (rho=0.5).

Table 6.3 shows the associations between the literacy percentile scores from Chapter 2, and the percentile scores of the working memory tests. The three PSTM tests had moderate to strong correlations with three of the four reading tests and these were significant in most cases (all correlations were above .4). Most of the significant correlations were with the two timed reading tests (the one-minute reading and the nonsense passage) and the Salford test, particularly with the word recall and the backward digit tests. The PSTM tests had no significant correlations with either spelling or writing.

Table 6.3: Correlations between the working memory measures and the literacy measures

	1 min Reading	Nonsense passage	Salford	TVTC nonword	Spelling	Writing
Digit Recall	0.499	<b>.551*</b>	0.525	0.133	0.113	0.117
Word Recall	<b>.59*</b>	<b>.63*</b>	<b>.677**</b>	0.501	0.436	0.083
Nonword Recall	0.459	<b>.578*</b>	0.42	<b>.596*</b>	0.303	-0.13
Block Recall	-0.459	-0.396	0.035	-0.198	-0.103	0.288
Mazes Memory	0.089	-0.028	0.361	-0.328	0.016	<b>.569*</b>
Listening Recall	0.354	0.395	0.3	0.202	0.246	-0.153
Word List Matching	<b>.615*</b>	0.506	<b>.599*</b>	0.319	0.346	0.296
Backward Digit	<b>.632*</b>	<b>.644**</b>	<b>.629*</b>	<b>.629*</b>	<b>.71**</b>	0.15

\* Correlation is significant at the 0.05 level (2-tailed)

\*\*Correlation is significant at the 0.01 level (2 tailed)

Of the two VSTM tests the only significant correlation was between the mazes memory assessment and the writing test. However, because percentile scores in both tests were usually zero, the results of the correlations must be treated with caution. The mazes test, unlike the block test, makes relatively high demands on motor performance when tracing the route through the maze. Thus, it is possible that the significant correlation may reflect impairments of motor coordination rather than visual memory.

In terms of the three tests of executive loaded working memory, the backward digit test had highly significant correlations with all the literacy assessments except for writing. The word list matching recall test had moderate to strong correlations with three of the reading tests, two of which were highly significant. In contrast, none of the correlations for listening recall were significant. This might be because manipulating digits is similar to manipulating and processing letters, whereas listening recall relies more on semantics. It is worth noting that the spelling test had only one highly significant correlation, which was with the backward digit test.

### **6.3: Discussion**

The aim of this study was to examine whether children with CP have difficulties with the working memory system. Previous studies have indicated that there may be impairments with PSTM and VSTM but a number of the studies involved children with CP who had communication difficulties. It was predicted that as the children in this study mainly had intact communication abilities the children would not be impaired on PSTM tests. In Chapter 5, it was shown that the children in this study had difficulties with visual and spatial perception which suggests that the children would have difficulties with tests relating to the VSTM component in working memory, and this might affect their abilities to develop literacy skills.

The discussion will be divided into three sections in which the findings regarding each component of the working memory system will be considered and compared with those from other studies. In addition, the correlations between components of the working memory system and literacy will be evaluated to better understand the links between these two sets of abilities.

#### **6.3.1: Verbal recall tests and PSTM**

The percentiles scores from the phonologically based recall tests (digit, word, and nonwords) were mostly in the typical or above typical ranges. Thus, most of the children did not appear to have impaired PSTM. These results differed from those reported in some of the studies of children with communication difficulties (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001) where the children with CP performed poorly in digit span tests in comparison to their mental-aged matched controls. Because the children with communication difficulties were unable to verbalise or vocalise, this may have affected their performance on the phonological tests even though the methodology

was adapted to accommodate the children's needs. Other studies of children with CP with and without communication difficulties (Bishop, 1985; Bishop and Robson, 1989; White et al, 1994) have indicated that the phonological memory spans in their participants were intact despite poor articulation. Many of the children in this study have slightly slower articulation or verbal output than typical children; however, like the children in the latter studies, this did not appear to affect their verbal memory spans. Their scores in the word recall test were particularly good apart from two children (Rob and Jon). The present findings are consistent with other test results where the children generally scored well in the CCC-2, the receptive language assessment and the two semantic tests (reported in Chapter 3).

Generally, the PSTM tests were successfully completed by most of the children including many of the poorer readers, as five of the poorer readers scored within typical levels on all three PSTM measures. This would seem to indicate that the preservation of the children's PSTM abilities were not necessarily related to their literacy difficulties. Several of the poorer readers had the lowest scores on the PSTM tests which might reflect the often reported link between phonological abilities and literacy (see Hulme and Snowling, 2009)

The significant correlation between the nonwords recall test and the TVTC nonwords reading test is corroborated by results reported in a study by Gooch et al (2011) of children with dyslexia and/ or ADHD. The children with dyslexia had poor results in the nonwords recall test and the phonemic decoding test (similar to the TVTC nonwords test).

### **6.3.2: The Visuospatial Sketchpad and VSTM**

As predicted, in contrast to the PSTM tests of the phonological loop, the percentile scores of the visual and spatial tests of VSTM were extremely poor. The results of the block test will be examined and discussed first followed by the mazes test.

All but two of the children had extremely low percentile scores in the VSTM tests which were mostly below the fifth centile. These results are similar to those in studies where the children with communication difficulties also scored below typical levels (Dahlgren Sandberg, 1997; Pueyo, 2009), and to a study of children with DCD (Alloway and Archibald, 2008) who had poor block recall results. Only two children scored well in the block test, both of whom showed slightly different patterns of cognitive abilities to the other children. Joe had typical visual perception scores in the visual tests in comparison to the other children which may explain his ability in the block test. On the other hand Jon scored badly in the verbal tests but has scored in the typical range in the block test.

Because children with CP have been identified as having problems with spatial awareness (Abercrombie, 1964), it was predicted that the children with CP would score poorly on the mazes memory test. The percentile scores showed that the children found this assessment extremely difficult, as many of the children had a percentile score of zero. This was because many of the children were unable to reproduce any of the mazes in the test.

There are a number of reasons why the children were unable to reproduce the pathways, such as: they were unable to visually perceive the maze pathways (figure closure: Menken et al, 1987; figure ground: Nagle and Campbell, 1998; disturbance: Stiers et al, 2002); they were unable to remember where the pathways went (Carlsson, 1997; visual memory: Arp and Fagard, 2005); or they were physically unable to reproduce the pathways (Abercrombie, 1964). Children with DCD (Alloway and Archibald, 2008) were also tested on



the mazes memory test, and they had much better success with this test in comparison to the block test. This is surprising as children with DCD often have difficulties with handwriting, and might be expected to have similar problems as children with CP.

There was a significant correlation between the mazes test and the writing (copying) test, but there were many percentile scores of zero, although this does not necessarily indicate that the children had problems for the same reasons. In one study (Dahlgren Sandberg and Hjelmquist, 1997) the children with CP, who were better readers, had higher scores in the Corsi block test than the poorer readers. However, in this study there were no significant correlations between the block test and the literacy tests and the better readers scored as poorly as the worst readers. The fact that even the better readers had very low scores on the two visual perception tests, together with an absence of correlations between visual perception and reading suggests that difficulties with visual perception was not a cause of the children's reading difficulties. However, the finding of a correlation between the mazes test and handwriting is of interest and would be an issue to pursue in further research as it is not clear whether the children's difficulties with both tests were due to difficulties with motor control, problems with visual perception (see Table A5.1, Appendix 5), or problems with memory, or a combination of all three.

### **6.3.3: The Central Executive and ELWM**

The word list matching test will be discussed alongside the backward digit test and the listening recall test as it may require greater skills at auditory processing and memory (Savage et al, 2007; Henry, 2010) and the use of phonological coding which are more compatible with the central executive of working memory.

The tests involving the central executive aspect of working memory had mixed results. The children found the listening recall test the most difficult with only three children gaining typical or very high scores. Only six children scored within the typical range of the word list matching test, while the children scored slightly better on the backward digit test with eight scoring within typical levels. All of the children got a reasonable score on this test with only three children scoring lower than the 5<sup>th</sup> centile. Looking at the backward digit test and the word list matching test together, there was a clear division between the better readers and the poorer readers apparent in the percentile scores. The backward digit test had five highly significant correlations with the four reading tests and the spelling tests while the word list matching test had highly significant correlations or relationships with three of the reading tests. These findings suggest that ELWM and reading abilities are related, and consequently it is possible that ELWM abilities play an important part in determining reading abilities in children with CP.

The majority of the poorer readers had difficulty with these processes which suggests that they had difficulties when processing demands were high because two tasks have to be completed at the same time, or they were unable to switch attention successfully between processes (Henry, 2012). Another possibility is that these two tasks also required a measure of visual processing or a recoding of a visual stimulus into a phonological form (Henry, Messer, Luger-Klein and Crane, 2012; Bacon et al, 2013). The backward digit task requires the child to hold a number of digits in the memory while simultaneously reversing them. One way to reverse the numbers would be to visualise them and turn them round before verbalising them in their new order. The high correlations between the backward digit and the reading and spelling tests may also reflect that digits involve symbols, and phonemes also involve symbols (letters).

The listening recall test produced the poorest performance of the three ELWM assessments. Most of the poorer readers had low scores but some of the better readers also did poorly. Out of the top three readers, only Lewis scored well at the 96<sup>th</sup> centile while Ian and Beth scored poorly, yet in the poorer readers group, two of the children, Jon and Chris, scored just below typical levels. The disparity between the percentile scores of the better and poorer readers was reflected in the weak correlations between the listening recall test and the literacy tests. Hulme and Snowling (2009) consider that the listening recall test (reading span) is a much more complex test and is more demanding of attention control in the central executive. The assessments for the central executive component generally threw up more difficulties for the children with reading difficulties, as the more able readers had higher scores, particularly with the word matching test and the backward digit test.

Thus, the complexity of the ELWM tests gave some indication as to why children with CP have difficulties with the development of their literacy skills, as they require a higher information processing load. There is also a consideration that the switching of tasks within the memory systems may cause problems for children with CP, particularly the poorer readers.

#### **6.3.4: Conclusion**

Overall, the findings from the assessments of the working memory system conformed to the expected areas of strength and difficulty, with the children generally gaining good scores on the PSTM tests, and scoring extremely poorly on the VSTM. The better readers and spellers within the group scored higher on the ELWM tests, and correlations between the working memory systems and the literacy tests could help to explain some of the literacy difficulties of this group of children.

## **Chapter 7: Discussion**

This thesis was designed to examine and investigate why many children with CP, who apparently have typical, or just below typical abilities and often have typical communication abilities, appear to have difficulties with some, or all, aspects of their literacy development. The over-arching questions relating to the thesis is whether children with CP:

- have impaired literacy abilities;
- have impairments in areas of cognition which might be expected, on the bases of previous research, to affect their literacy difficulties;
- have cognitive abilities which relate to their literacy abilities.

This chapter brings together the findings of the studies in this thesis and draws conclusions about the literacy development of this group of children with CP. This is followed by a section on the limitations of the study, and a section on suggestions for future research.

### **7.1: Summary of Findings**

This section contains a review and a discussion of the five studies of children with CP, comprising of: literacy abilities; learning or cognitive abilities; phonological processing abilities; visual and spatial perception; and working memory abilities.

#### **Study 1: Literacy abilities of the children**

Four reading tests, a spelling test and a handwriting (copying) test were completed by the children, which included both timed and untimed tests. The majority of children had difficulties with literacy with only three children out of the fifteen scoring at typical levels in all the reading and spelling tests.

Table 7.1: Summary of the results of the literacy tests in percentiles

	DST-J one minute reading test	Nonsense passage test	Salford reading test	TVTC non-word test	2 min Spelling test	1 min writing test
Children with typical scores: N=15	3	5	5	4	4	0
Mean	12.4	22.7	14.7	16.87	12.6	2.6
Standard deviation (SD)	19.98	27.6	17.89	24.58	11.5	2.6

Of all the reading tests, the children found the DST-J one-minute reading test the most difficult, and the Nonsense passage reading test the easiest as shown by their percentile scores (mean scores of 12.4 and 22.7 respectively). The levels of performance achieved by the children in decoding (eleven of the children scored below the tenth centile) suggest that many of them were unable to decode by sounding out and making sense of the words (Frith, 1985; Ehri, 2005).

The low scores on the DST-J one minute reading test may have been because it was made up of lists of single words without any contextual information, leading to phonological strategies or whole-word decoding being employed, which many of the children found difficult to do. It is also possible the children were delayed in building up a sight-word vocabulary (Singleton, 2002). These difficulties indicate that many of the children were in a pre-reading or early reading stage (Ehri, 2005), despite chronological ages of between 6.5 years and 11.6 years. Both of the reading tests were timed, so speech hesitations might have influenced performance, however observations made during the tests showed that the children had enough time to complete them. A related finding was that the poorer readers found the TVTC nonwords test, which involved decoding, very difficult showing that they were unable to use phonological strategies, and again suggests that they were at a pre-alphabetic (Ehri, 2005) or logographic (Frith, 1985) stage of reading development. The Nonsense-word passage test was made up of real word sentences which included

nonwords, so other strategies could be used including context and graphotactic strategies to help with decoding (Frith, 1985; Snowling, 1987; Nation, 2005), and this may explain the relatively better performance of the children on this test.

The spelling results were interesting in that the better readers had poorer percentile scores than they obtained for their reading, while the poorer readers had better percentile scores for their spellings than for the reading tests. This is consistent with longitudinal research (Caravolas et al, 2001) where younger typical children develop phonological strategies which feed into the children's spelling skills before the children utilise them for reading.

All of the children had severe problems with handwriting and all test scores were below the tenth percentile in this assessment. While motor coordination problems may have led to lower scores it was noticeable that many of the errors were due to spatial difficulties such as placement of letters and words, or being unable to reproduce or copy individual letters. This corresponded with previous research into handwriting difficulties (Abercrombie, 1964; Koeda et al, 1997; Stewart et al, 1997) where issues had been raised about whether the children had problems with writing due to a motor difficulty, a visual or spatial perception difficulty or problems with reconstructing symbols.

Correlations were highly significant across all the spelling and reading tests, indicating that the children had a similar profile of abilities across most of the literacy assessments, which supported findings by Dorman (1985; 1987) and Dahlgren Sandberg (2001); although, as already noted, even the children who had percentile scores in the typical ranges for reading tended to have lower scores of spelling and writing. It is worth noting that the weakest correlations were between the reading and spelling tests, in relation to the handwriting test which indicate that the children's impairments in the writing test were not necessarily

related to phonological awareness or processing, but involved different skills (Bumin et al, 2008; Steffler and Critten, 2008). For the group as a whole, the majority of the children with CP had scores below the tenth percentile for all the reading, spelling and handwriting tests. These scores suggest that most of the children had significant literacy difficulties and this confirms the initial expectation about children with CP. However, not all the children with CP were poor at decoding and the better readers showed evidence of use of multiple strategies (Plaut, 2005), and this variation was helpful in examining relations between cognitive processes and literacy.

### **Study 2: Verbal and non-verbal abilities of the children**

Five assessments comprising a non-verbal test and four verbal assessments (Raven's Matrices, Children's Communication Checklist; Receptive vocabulary (DST-J); Mill Hill Vocabulary scale; Semantic fluency (DST-J)); were completed to identify whether the children had general learning difficulties or particular areas of weakness, or even had strengths in non-verbal reasoning or receptive and semantic language abilities. There was a very large discrepancy between the percentile scores of the Raven's Matrices, a non-verbal assessment, where the children had percentile scores in the atypical range below the ninth centile (for all the children except one) and the vocabulary (verbal) tests where the majority of the children had typical scores (see Table 7.2). This discrepancy was surprising as one would normally expect the non-verbal and verbal ability tests to correspond (Bishop et al, 1990; Asbell et al, 2010). The Raven's Matrices test relies on the analysis of visual material and consequently performance on this test may have been influenced by the visual processing abilities of the children (see Study 4 below).

Table 7.2: Descriptive statistics of percentile scores: verbal and non-verbal abilities

	Ravens Matrices	CCC2	Receptive vocabulary	Mill Hill	Verbal fluency
Means	3.53	56.21	36.13	36.53	41.07
SD	6.52	28.9	18.5	19.5	31.86
No of children with typical scores	1	11	10	12	9

An examination of the tests showed that there were weak non-significant correlations between the percentile scores of the Raven's Matrices and those of the verbal tests, which might be expected given the difference between the percentile scores of the respective tests. However, even amongst the verbal tests there was only one significant correlation (see Table 3.2, Chapter 3); this was between the receptive vocabulary test and the Mill Hill semantic test, which corresponds with findings by Asbell et al (2010). It was interesting that the generally high percentile scores of the communication checklist (CCC2, Bishop, 2003) did not correlate with the other vocabulary tests and suggests that receptive or semantic skills are not necessarily predictive of, or related to, communication abilities in children with CP. Thus, with these children forms of language abilities did not appear to be closely related to one another.

An examination of the relationships between these four assessments and the literacy tests (see Table 7.3) revealed that there were weak non-significant correlations between the Raven's Matrices and the reading and spelling tests. This is consistent with the distribution of percentile scores; the better readers scored as poorly on the Ravens as the poorer readers. Furthermore, this suggests that the Raven's Matrices test may not be a valid assessment of non-verbal cognitive ability for children with CP possibly due to the children having difficulties with visual processing (Dahlgren Sandberg and Hjelmquist, 1997; Pueyo



et al, 2008; Dahlgren Sandberg, 2001; Jenks et al, 2007; Larssen et al, 2008; Peeters et al, 2008, 2009a, 2009b, 2009c; Holck et al, 2009; Asbell et al, 2010).

**Table 7.3: Correlations between literacy and other tests (only significant correlations and / or those greater than 0.4 are shown)**

	I minute reading test	Nonsense word passage test	Salford reading test	TVTC nonword test	Spelling test	Writing test	No of children with typical Scores
<b>Ability tests</b>							
Ravens							1
Receptive vocab							10
Mill Hill							12
Verbal fluency	0.43		0.46				9
CCC2 test							11
<b>Phonological tests</b>							
Phonemic segment	0.59*	0.72**	0.74**	0.42	.54*		5
Alliteration fluency			0.46	0.57*			5
RAN	0.43	0.45				0.48	4
<b>Visual Tests</b>							
V memory							3
V seq memory	0.63*	0.67**	0.67**	0.62**	0.63**		6
V spatial relation	0.47	0.52*	0.48				5
V discrimination			0.43				1
Form Constancy							1
Fig ground							4
Fig closure							1
Total V P							1
<b>Working memory</b>							
Digit recall	0.5	0.55*	0.53*				10
Word recall	0.59*	0.63*	0.68**	0.5	0.4		13
Nonword recall	0.46	0.58*	0.42	0.59*			11
Block recall							2
Mazes memory						0.57*	0
Word Matching	0.62*	0.5	0.6*				6
List recall		0.4					3
Backward digit	0.63*	0.64**	0.63*	0.63*	0.71**		8

\*\* Correlation is significant at the 0.01 level (2 tailed); \* Correlation is significant at the 0.05 level (2 tailed)

There were correlations of above .4 between the verbal (semantic) fluency assessment, with the one-minute reading test and the Salford reading test, suggesting a trend with the better readers having better semantic categorisation skills (in common with studies by Nation, 2005; Hulme and Snowling, 2009). In relation to this, it is worth pointing out that many of the children scored well on the verbal tests and some of the poorer readers got typical scores on the verbal tests. Although research into dyslexia usually indicates that poor verbal abilities are associated with difficulties with reading (Snowling, 1987) this study, in common with Lord (1934) and Dorman (1985), suggests that there was no significant association between language and literacy, and that impaired verbal abilities were not responsible for literacy difficulties. The weak correlations between the handwriting test and all the ability tests also imply that the children's handwriting skills were not related to their non-verbal or language abilities.

To summarise, the children's low scores on the Raven's Matrices non-verbal ability measures would typically be associated with the children having significant or severe learning difficulties, but their much higher percentile scores on the verbal assessments suggested that the children did not have general learning difficulties. The weak correlations between the literacy percentile scores and the percentile scores of the ability tests provide little in the way to support the idea that the children's cognitive abilities are strongly associated with the children's literacy difficulties.

### **Study 3: Phonological processing abilities of the children**

According to the percentile scores from the tests related to phonological abilities tests (phonemic segmentation; verbal fluency and RAN tests); the majority of the poorer readers had poor phonological abilities. In addition, some of the children had very low percentile scores on the RAN test, which is often regarded as an assessment of phonological abilities

(Hulme and Snowling, 2009); five of the children only had scores at the 1<sup>st</sup> percentile (see Table 7.4). Generally the better readers had the better phonological processing abilities but it was a mixed picture with only two of the better readers having typical scores across all three tests.

Table 7.4: Descriptive Statistics of percentile scores in Study 3: Phonological Abilities

	Phonemic segmentation	Verbal fluency	RAN: Rapid naming
Means	21.3	19.7	18.6
SD	24.1	19.8	27.9
No of children with typical scores	5	5	4

There were no significant correlations between the three tests, but there was a moderate non-significant correlation of above 0.4 between the phonemic segmentation percentile scores and those of the RAN test. The better readers generally had scores in the typical ranges on the phonemic segmentation and verbal fluency tests (reflecting research by Vellutino and Fletcher, 2005; Hatcher and Snowling, 2002). Some of the better readers had low percentile scores on the RAN test (1st, 15th and 9th percentiles). This may have been due to hesitations in their speech rather than indicating that they have poor phonological abilities (Bishop, 1985).

Looking at the relationships between the children's phonological assessments and the literacy percentile scores, there were some correlations showing significant and highly significant relationships between the phonemic segmentation scores and three of the reading tests and the spelling test (see Table 7.3). There was also a significant correlation between the verbal fluency test and the TVTC nonwords reading test. The significant correlations between the tests show that the better readers had better phonological abilities. Thus, as one might expect from findings regarding the associations between phonological abilities and dyslexia (Hulme and Snowling, 2009) the impaired phonological

abilities of some of the children could have been a contributing factor in their poor reading abilities. This supports the phonological representation hypothesis proposed by Hulme and Snowling (2009).

#### **Study 4: Visual perception and visual spatial abilities of the children**

The majority of the children had very low percentile scores on the visual and spatial perception tests: visual memory, visual sequential memory, spatial relationships, visual discrimination, form constancy, figure ground, figure closure and a total visual perception score (reflecting research by Dolphin and Cruickshank, 1951; Stiers et al, 2002). Many of the scores were below the tenth centile for both good and poor readers. Only one child achieved typical scores in all the tests (see table 7.5).

Table 7.5: Descriptive Statistics of percentile scores in Study 4: Children’s Visual Abilities

	Visual memory	Visual sequential memory	Spatial relation	Visual discrim	Form constancy	Figure ground	Figure closure	Total VP
Mean	10	17.7	21.9	7.53	4.6	14.73	9	8.8
SD	18.61	18.86	32.4	19.92	8.66	23.71	22.5	17.47
Numbers of typical scores	3	6	5	1	1	4	1	1

The most notable finding was that the better readers scored most highly, and in the typical range, in two of the tests. The test for visual spatial relationships showed that five of the best seven readers were able to make sense of visual spatial information (scoring between the 25<sup>th</sup> and 95<sup>th</sup> percentiles). This test assesses the relationship of shapes, e.g. of individual letters/ individual words. The test for visual sequential memory indicated that the best five readers were able to hold sequences of visual information in their memories (scoring between the 25<sup>th</sup> and 55<sup>th</sup> percentiles). These two tests signal a noticeable difference between the poorer readers and the better readers, and a lack of skills in these

tests suggests reasons why the poorer readers with CP were developing literacy skills more slowly.

Correlations between the visual tests showed clear distinctions between the types of tests, and suggested that there were two groups of visual abilities. The first group consisted of visual memory, visual sequential memory, visual spatial relationships and visual discrimination, and all these tests had strong associations with each other with significant or highly significant correlations. In contrast, the second grouping of form constancy, figure ground and figure closure had weak correlations with each other. The second group also had weak correlations with the first group. This suggested that the two groups of tests were measuring different aspects of visual perception. As might be expected, all the tests had significant or highly significant correlations with the overall visual perception score except figure closure.

Correlations between the visual and literacy tests (see Table 7.3) showed that for most of the tests there were no significant correlations between visual perception and the reading assessments. There were two exceptions to this: the spatial relationship test and the test for visual sequential memory. For the spatial relationships test, there were two moderate correlations of above .4 with the one-minute reading and Salford reading tests, and one significant correlation with the nonwords passage test. However, there were notable significant correlations between visual sequential memory and the reading and spelling tests; there were five highly significant correlations, and these provided the strongest of the associations between the literacy tests and all the other cognitive measures. This is a very interesting result. It suggests that children with CP need to have this specific skill to be able to read and spell, or, perhaps, will develop this skill while learning to read and spell. Other visual test measures that have been used in studies for children with literacy

difficulties (Evans, Drasdo and Richards, 1994; Stein and Walsh, 1997) often do not include a test for visual sequential memory, and in a study of children with CP and poor communication, there were no significant correlations between visual sequential abilities and reading (Dahlgren Sandberg, 1997). It is difficult to know whether a lack of this particular skill just pertains to children with CP who have more typical verbal abilities together with impaired reading skills.

To summarise; all the children, bar one, had low scores on the majority of the visual and spatial perception tests. However, most of the better readers had scores in the typical range for the visual sequential memory test. The results of the correlations between the tests showed two distinct groupings which may have some bearing on their associations with other cognitive skills (see Appendix 5: Correlations between the cognitive tests). The spatial and, more particularly, the sequential memory tests correlated highly with the reading and spelling tests which suggests that the poor visual memory of many of the children may have affected their literacy abilities. This finding may not have been reported in relation to literacy development before because many studies failed to test for visual sequential memory and, in children with literacy difficulties, it has not been suggested that this capacity is necessary for literacy development.

### **Study 5: Working memory**

The children were tested on three aspects of the working memory system: phonological short term memory (PSTM); visual short term memory (VSTM) and executive loaded working memory (ELWM); each of which will be considered separately.

Most of the children showed relative strengths in the short-term verbal recall measures of PSTM with many having very high scores (four scores at ceiling level), including those children with low scores on the literacy assessments (see Table 7.6).

Table 7.6: Descriptive Statistics of percentile scores: Working Memory Abilities

	Digit Recall	Word List Recall	Nonword List Recall	Block Recall	Mazes memory	Listen Recall	Word List Matching	Backward Digit
Mean	51.8	66.33	55.2	8.27	1.53	24.13	22.13	30.4
SD	34.12	33.06	38.65	16.6	3.5	34.88	29.33	25.26
Number: Typical scores	10	13	10	2	0	3	6	8

Many of the children performed poorly on the tests of phonological awareness and related abilities; in contrast almost all the children had phonological STM scores in the typical range. Although phonological STM is often seen as a component of phonological abilities (Hulme and Snowling, 2009), these findings suggest that in children with CP there are problems of phonological awareness, particularly segmentation, but fewer problems with phonological STM. This contrasts with the research concerning children with CP with poor communication abilities who scored poorly in comparison to mentally-matched controls in PSTM tests (Dahlgren Sandberg and Hjelmquist, 1997; Dahlgren Sandberg, 2001; Larsson and Dahlgren Sandberg, 2008).

In contrast, most of the children scored very poorly in the tests involving VSTM. Only two children scored in the typical range in the block test and all of the children scored in the low atypical range in the mazes memory test, most children achieving a percentile score of zero (nineteen scores at floor level on both tests, a profile which, as mentioned previously, should be taken into account when interpreting low correlations between variables). The finding that even the better readers had very low scores on the VSTM tests suggests that

this ability was not necessarily an influence on the children's literacy performance. The results of the Corsi block test replicated studies (Dahlgren Sandberg and Hjelmquist, 1997, Dahlgren Sandberg, 2001; Jenks et al, 2007 and Larsson and Dahlgren Sandberg, 2008) in which children with CP performed poorly in comparison to control groups.

The children achieved a range of percentile scores on the three executive loaded working memory tests (listening recall, word matching and backward digit), and this replicated findings of other studies of children with CP (Jenks et al, 2007; Larsson and Dahlgren Sandberg, 2008; Pueyo et al, 2009). Many of the children with the highest literacy abilities also had scores in the typical range on these tests. It also was the case that many but not all of the poorer readers had scores on these three tests which were in the low atypical range.

Correlations between these tests and the literacy tests showed that there were a number of significant and highly significant correlations between the PSTM tests and the reading tests (see Table 7.3). Even so, it would seem that PSTM was not a cause of the children's reading difficulties; if this had been the case then the PSTM scores of the poorer readers would have been in the atypical range. The significant correlations between the PSTM scores and the literacy assessments seem to suggest that higher PSTM abilities were of help to the children's literacy abilities.

The only significant correlation between the literacy tests and the VSTM tests was the handwriting test, which suggests that the problems encountered by the children in the handwriting test was related to the children's difficulties with remembering the shapes of the maze routes – or reconstructing them (Abercrombie, 1964). The low scores of the mazes memory task also have significant correlations with visual spatial relationships, and



highly significant correlations with visual discrimination and visual perception, however, there were no significant correlations with the block recall test (see Appendix 5: Correlations between the cognitive scores). The lack of correlations between VSTM and literacy, replicating the findings of Dahlgren Sandberg and Hjelmquist (1997), may have been due to many children performing at or near to floor level on the VSTM tests.

The correlations between the executive loaded working memory tests and the literacy tests showed that backward digit recall had the highest number of significant associations with the literacy test scores. It is not entirely clear why the other tests did not have as strong a relationship with literacy abilities. One possibility is that the ability to process symbols such as digits and letters, as in the backward digit test, is more relevant in the processing of words than the stimuli in the other tests. Another possibility concerns the links between executive loaded working memory with visual perception; the backward digit test had no significant correlations with the visual and spatial perception tests (see Appendix 5: Table A5.1); while the other two ELWM tests had three significant and six highly significant correlations with the visual tests. It is difficult to understand why these correlations are present, but the children's lack of visual and spatial perception appears to be associated with a number of other cognitive processes (Hulme and Snowling, 2009) and, ultimately, on the development of literacy skills.

Thus, the verbal recall tests (PSTM) and the backward digit test had the strongest significant correlations with the reading tests, while the visual short term memory tests were not associated with reading abilities.

## 7.2: Overall Conclusions from the studies

Looking at the over-arching questions at the beginning of this chapter:

1. Many of the children had impaired literacy abilities with tests showing that they had significant difficulties with reading and spelling and all the children had problems with writing (copying).
2. The children had impairments in a number of cognitive measures which might be expected to affect their literacy abilities. Most of the children had low percentile scores in specific areas of cognitive functioning. There were low percentile scores on tests which involved visual processing as evidenced by difficulties with the Raven's Matrices test; aspects of visual perception and visual memory as illustrated by visual sequential memory test; the Corsi block test and the mazes memory test. Many of the children also had impairments in the cognitive measures for phonological abilities, phonemic segmentation, verbal fluency and RAN; and the measures for ELWM.
3. The main developmental or cognitive areas which appear to relate to the literacy abilities of the better readers and spellers have been identified in this study as:
  - Phonological processing particularly phonemic segmentation. The better readers were able to chunk words into syllables or finer grains of sounds; this finding would be expected from the phonological representations hypothesis of Hulme and Snowling (2009). However, it is worth noting that most of the children had PSTM scores in the typical range, which is surprising given that phonological awareness and PSTM are often regarded as being different aspects of children's phonological abilities (see Hulme and Snowling, 2009). This suggests that the literacy development of these children might be promoted by further work on

phonological abilities, particularly phonemic segmentation (see section 7.4:

Teaching implications).

- Specific areas of visual and spatial perception. The children who were the better readers had scores in the typical range for visual sequential memory and, to a lesser extent, the test for visual spatial relationships; these two aspects of visual perception appear to be crucial elements for reading and spelling ability in children with CP. Although visual processing difficulties have been discussed as a cause of dyslexia (Everatt, 2002), there has been almost no discussion of visual sequential memory abilities in relation to the development of literacy. The findings presented in this thesis suggest that support for visual memory might help relatively able children with CP in the development of literacy and perhaps other abilities (see Section 7.4: Teaching implications and Appendix 5: Correlations between the cognitive tests).
- The central executive of working memory. Generally the better readers had higher scores in these tests suggesting that the poorer readers had difficulties with holding information in the memory while performing another task. There have been suggestions about ways to support ELWM (Gathercole, Alloway, Willis and Adams, 2006) and various interventions have been proposed (Henry et al, 2013).

Thus, phonological awareness, visual sequential memory and executive loaded working memory were all predictors of literacy abilities, and the implication is that impairments to these cognitive processes may have contributed to many of the children's literacy impairments.

### **7.3: Dyslexia and CP: a comparison of similarities and difficulties**

Due to a dearth of suitable and relevant literature regarding literacy difficulties in children with CP who can speak, comparisons have been made to studies regarding children with dyslexia. Dyslexia is usually considered to involve literacy difficulties in the presence of typical levels of other intellectual abilities. The finding that children with CP had low scores on the Raven's Matrices assessment (Raven, Raven and Court, 2008) could be interpreted as an indication that the children with CP had general learning difficulties which was a cause of their literacy impairment. However, a broader consideration of the children's communication and other abilities, together with evidence of their difficulties with visual stimuli, suggested that the children did not have general learning difficulties, but instead more specific areas of impairment which had an effect on their literacy development.

This section compares the results of the literacy and cognitive measures of children with CP with the literature pertaining to the literacy and cognitive difficulties of children with dyslexia. As ten of the group of fifteen children with CP had severe difficulties with literacy, the results of the poorer readers will be compared to children with dyslexia.

#### **Similarities**

Both children with dyslexia and the poorer readers with CP have difficulties with phonological awareness. Phoneme segmentation (deletion) tests; verbal fluency (alliteration) tests; and RAN tests are known to be problematic for children with dyslexia (Hatcher and Snowling, 2002; Hulme and Snowling, 2005; Vellutino and Fletcher, 2005), and the poorer readers with CP performed poorly on these tests. This suggests that children with dyslexia and poorer readers with CP may have causal relationships in common; with deficiencies in phonological awareness and phoneme/ grapheme mapping, and deficiencies in word identification and spelling (Hulme and Snowling, 2005; Vellutino and Fletcher, 2005 regarding dyslexia).

Children with dyslexia have also been identified as having difficulties with verbal or phonological short term memory (Hatcher and Snowling, 2002; Henry, 2012). Generally the children with CP performed well in the tests for PSTM, however the poorer readers had lower scores and there were significant correlations between the PSTM tests and the reading tests (see Table 7.2) suggesting that the poorer readers with CP and children with dyslexia have difficulties with PSTM which may affect their reading development.

Children with dyslexia are also considered to have poor working memory skills involving the central executive subsystem (Henry, 2012). The poorer readers with CP also performed poorly on the ELWM tests, while the better readers generally had typical scores. The word matching assessment and the backward digit test had significant and highly significant correlations with the reading tests, which suggests that both children with dyslexia and the poorer readers with CP have problems with ELWM, and this may be due to difficulties with concurrent processing (Henry, 2012 re dyslexia).

### **Differences**

While there have been reports that children with dyslexia have problems involving vision, particularly the magnocellular pathways (Everatt, 2002), this appears to only affect groups of children and not all children with dyslexia (Vellutino and Fletcher, 2005; Hulme and Snowling, 2005). In contrast the entire CP group had difficulties with the visual perception and spatial tests but only the visual sequential memory test and, to some extent; the spatial perception test had correlations with the children's literacy abilities. There do not appear to be studies in which visual sequential measures have been included in assessing children with dyslexia so it is not possible to compare this.

## **Conclusion**

Many of the difficulties with literacy development found in children with dyslexia are similar to the difficulties found in the CP group of children with reading and spelling problems. Deficiencies with phonological processing and STM are common in both groups, and problems with visual processing may also be discovered in the dyslexia group although results have been inconsistent.

Many of the teaching approaches used to help children with dyslexia could also be used to help literacy development in children with CP, and these interventions are discussed below.

### **7.4: Teaching Implications**

The studies in this thesis were designed to identify the cognitive difficulties of a group of children with CP, and the results of the cognitive assessments were correlated with the children's literacy abilities. Table 7.3 provided a breakdown of the significant correlations, and associations above .4 between the tests. The correlations highlighted the specific areas of cognition which may have impacted on, or caused difficulties with, the development of literacy skills. The implications of these findings for teaching practice are considered in this section by outlining interventions which might address these difficulties. Hulme and Snowling (2009) suggest that there are two issues involved: whether the difficulty or impairment can be overcome by an educational or therapeutic approach, and whether the impairment is irreversible so that the approach has to encompass alternative ways around the difficulty. The following section is divided into two parts: interventions for phonological processing; and interventions for visual processing and memory. These outline a number of recommendations designed to address the cognitive difficulties that were found to be related to literacy impairments, including phonological awareness, visual and spatial perception, and phonological STM, visual STM and ELWM. These approaches

have also been selected to take into account the children's difficulties with motor coordination when learning these basic skills.

#### **7.4.1: Interventions for Phonological Processing**

The results from three phonological tests (DST-J) used in Study 3 (see Chapter 4) suggested that the poorer readers were unable to identify initial letter sounds, and segment or delete syllables and individual letters from given words. Phonological processing skills are considered to be important for the development of reading and spelling (Caravolas et al, 2001; Goswami, 1999) as it is believed that segmentation helps with the understanding of the relationship between the alphabetic structures of phonemes and graphemes (Snowling, 1987). Segmentation also has links with verbal memory in children with dyslexia (Snowling, 1987; Hulme and Snowling, 2005)

There are a number of teaching activities which should help in the acquisition of phonological skills, and these are outlined in Letters and Sounds, Phase 1, page 4 (DfES, 2007): general sound discrimination – environmental sounds, instrumental sounds, body percussion; rhythm and rhyme; alliteration; voice sounds; oral blending and segmentation. The DfES (2007) advises that all of these activities can be taught for up to six weeks before actual letters are introduced.

##### **1. Listening to, identifying and copying sounds in the environment**

Before (or alongside) teaching the alphabet, it would be beneficial for the children to experience a number of activities designed to develop their listening and attention skills in relation to sound segments (Layton and Deeny, 1996). Sounds such as those heard in the playground, a busy street or a farmyard can be identified using computer programs such as Clicker 5: Sounds Around (Crick Software, 2012) and copied using the children's own voices

or musical instruments. The street scene in Figure 7.1 includes sounds of a bus engine, a road drill, a busker playing a guitar, a bottle bank and the beeping of a Pelican crossing.

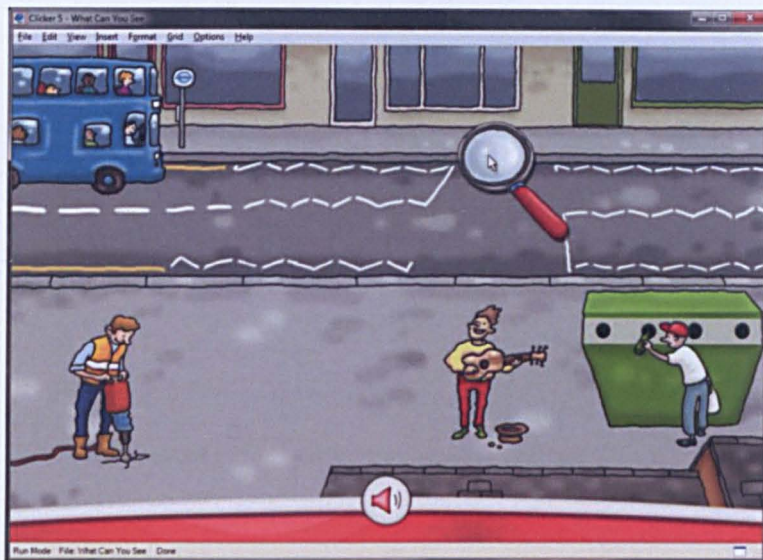


Figure 7.1: Street scene (Clicker Phonics) designed to develop listening skills and phonological awareness

## 2. Rhythm and rhyme

Several of the poorer readers had difficulties with the rhyme test (see Chapter 4, Table 4.2).

A number of studies have shown the importance of developing knowledge of rhyme by learning nursery rhymes, and that there are links between phonological and rhyme awareness and reading development (Bradley and Bryant, 1989; Layton and Deeny, 1996).

Relevant activities which may be of help are:

- Clapping and beating rhythms; copying and initiating rhythms and tunes; syllables in words (Layton and Deeny, 1996; Ott, 1997)
- Nursery rhymes (chanting and singing)

## 3. Alliteration: Onset/rime activities

The poorer readers had difficulties with the verbal fluency task in which words beginning with a specified letter have to be produced within a time limit. Activities to promote



phonological awareness, including the identification of initial letter sounds or phonemes in words, are considered to be important in the development of reading skills (Bradley and Bryant, 1983; Goswami, 1999). As well as learning nursery rhymes, games such as 'I-Spy' and the 'Tray Game' (where objects have the same initial sound, e.g. car, can, cat except for an odd one out) are fun for children to do. Another activity is where the initial sound changes but the 'rime' stays the same, e.g. hug, jug, dug (see Figure 7.2).

#### 4. Oral blending and segmenting

The poorer readers and spellers in the CP group had difficulties with identifying individual sounds in words, and being able to manipulate or delete those sounds. It is also important for them to be able to remember the sounds correctly in sequence, particularly when spelling (Snowling, 1987). The children need to be taught how to segment the sounds in words, e.g. c-a-t, as well as being able to blend individual sounds into a word. Relevant activities can include 'I spy' and 'Toy talk' where one-syllable words with two or three phonemes are sounded out and identified.

Phase 2 of Letters and Sounds (DfES, 2007) introduces letter identification and promotes the blending and segmentation of letters. There is a recommendation that sets of letters are taught in sequence, e.g. week 1: letters s,a,t,p; and these letters are blended and manipulated into words and non-words. The DfES recommends that magnetic letters can be used for this activity but children with CP often find these letters difficult to pick up and move.



Figure 7.2: Phoneme/ grapheme associations

The children are given pre-formed letters which are attached onto boards using Velcro which stops the letters from sliding. The children are encouraged to sound out the words they have made building up phoneme/ grapheme associations. This photo shows Linda working on onset/ rime: hug, dug, jug, etc.

Another resource that can be used to help children with CP with early spelling skills is with the use of letter flips (Edtech, 1990). Children, who find writing difficult or plastic letters difficult to pick up, can learn to spell and read simple cvc or ccvc words.



Figure 7.3: Using a letter flip

Teachers can add the number of letters they wish to the flip, and target the letters/ words they wish the children to learn.

There are a large number of published resources available for schools to use to teach synthetic phonics apart from 'Letters and Sounds' such as Jolly Phonics (Lloyd, 1992); Teaching Handwriting, Reading and Spelling Skills (THRASS) (Davies, 2006); and Read, Write, Inc. (Miskin, 2011). A comparative study was completed on Jolly Phonics and THRASS to see determine the best method for teaching phonics (Callinan and van der Zee, 2010). The results indicated that there were not many differences in the outcomes but one of the factors was the time of day in which the interventions took place. It was found that the best time for teaching phonics was immediately after registration at 9.15. Another factor was if the teaching groups were divided into ability groups.

#### 7.4.2: Interventions for Visual Processing and Memory

The majority of the children had difficulties with the visual and spatial perception assessments and the visual STM tests, and two tests: visual sequential memory and the spatial relationship test were significantly correlated to the reading and spelling tests. The following interventions can be used to aid in the development of the children's visual perception and visual memory skills

##### 5. Letter writing/ identification

The mazes memory test in the WMTB-C (Pickering and Gathercole, 2001) indicated how difficult it was for the children to remember simple pathways of lines which they had to copy, and this test had a significant correlation with the handwriting test. The mazes memory test also had significant correlations with subtests in the visual and spatial perception tests (see Table A5.1 in Appendix 5). This suggests that the children's difficulties with handwriting might have been caused by problems with visual memory as well as coordination difficulties. Thus, children with CP might benefit from specific interventions to help them remember shapes of letters and how to write them.



Figure 7.4: Making dough letters

The children were given magnetic letters to help them with letter identification and associated letter sounds. The picture shows Joe making letter shapes out of dough, copying the magnetic letters, which helped him to identify each letter and remember how they were shaped.

In the last few years, digital tablets have become available to use in schools, and apps have been developed to help promote the teaching of handwriting skills. There are a number of

apps available to help children learn to write individual letters such as 'abc Pocket Phonics' (Apps in My Pocket, 2010); 'Bobblewrite' (Leafcutter Studios, 2011) and 'English Cursive Letters Practice' (Brainstop, 2013). The apps show children how to write letters using the correct pathways, and may help children to develop motor memory (Ott, 1997; Asher, 2006; Graham, 2010; Vintner and Chartrel, 2010) and aid in developing schemas for visual memory representations (Hulme and Snowling, 2009).

## 6. Visual memory skills

Visual sequential memory was the most highly correlated cognitive ability with reading and spelling, and consequently may be an important skill in the development of literacy ability. A search of the techniques that can be used to develop visual sequential skills did not identify any research-based investigations of this subject. However, a related search identified a number of approaches recommended by occupational therapists such as Ecole le Sommet School (2013) and Calderdale and Huddersfield NHS (2013). These approaches are based around asking children to create or remember sequences or arrays of visual stimuli in specific order, and involve practical and verbal responses.

Ideas for activities include:

- Make patterns with beads, stickers, 2D shapes or 3D shapes, and ask the children to continue the pattern. Children can be encouraged to verbalise the pattern to reinforce learning. Make the patterns more complex as the child improves.
- Board games such as Silly Sandwiches, see Figure 7.5.



**Figure 7.5: Silly Sandwiches**

Children have to remember what silly objects were put in their sandwiches. This game can be graded from remembering 2-3 objects, 4, 5, 6, and more.

- Tray games using missing objects or adding objects. Place 5-10 small objects on a tray. Have children look at it for 1 minute. Encourage them to use strategies such as verbalising what they see. Then remove one or two objects. What is missing?
- Arrange a sequence of objects e.g. fork knife spoon in order of size, small to large, then mix the sequence and get the child to arrange them.
- What happens next? Make from comic strips or buy 'sequence cards' of everyday situations and ask child to sort in correct order.
- Recall and sequence the days of the week and months of the year, using magnetic words or flash cards.
- Recall and sequence numbers up to 10, 20, 100; or letters of the alphabet.
- Miming games or charades. Acting out sequences, such as making a cup of tea.
- Hangman or junior scrabble.
- Spell help, try writing partial words and getting the child to fill in. Try making letters and words with play dough (see Figure 7.4). Some children find singing their spelling helps them to remember.

#### **7.4.3: Planning and teaching interventions**

Lessons are usually made up of a number of components, for example, reading a familiar book, followed by an activity to develop phonemic awareness, followed by handwriting

practice. Many reading interventions (Wearmouth and Soler, 2002) have specific time guides such as three times a week over a twelve week period, but Schnorr (2011) suggests that her intervention can be ongoing over years, alongside other literacy lessons, and that the frame can be adjusted to the children learning abilities and their progress.

Lesson components	Possible materials
<p><i>Reread familiar book (3–5 minutes):</i> The teacher guides students through a review of reading behaviors through brief modeling and reminders (e.g., directionality, looking at print, voice–print matching by echo reading). Students reread the book with the lowest possible teacher support and focus on enjoyment, success, fluency, and being “readers.”</p>	<p>Print or electronic texts from prior lessons, laptop, iPad or desktop computer, touch screen, accessible mouse or switch, or screen reader software for echoing e-texts</p>
<p><i>Phonemic awareness, phonics, and word work (5–7 minutes):</i> The teacher provides brief, focused modeling and practice of skills for current goals through interactive, teacher-led activities (e.g., identifying letters and sounds in isolation, making words, word sorts).</p>	<p>Picture cards; letter cards, pocket chart, or alphabet chart; electronic formats for teacher-prepared lessons in making words, picture sorts, or word sorts (e.g., software, touch screen, interactive whiteboard)</p>
<p><i>Shared reading of new text (15 minutes):</i> The teacher provides a rich, interactive book introduction to activate and build background knowledge, discuss and connect vocabulary to known words and experiences, preview text and pictures, and so forth. Then, the teacher and students read the new book together with <i>high</i> teacher support (e.g., echo and choral read each line or page), stopping occasionally to model or prompt thinking about the text. Next, the teacher and students reread the new text with <i>less</i> teacher support, focusing on accuracy and fluency, with little or no stopping. Finally, the teacher and students discuss and respond to the text, with the teacher modeling, writing, and supporting student response.</p>	<p>Print or electronic texts with book features: predictable language (e.g., pattern sentences, strong picture cues), varied genres, and topics that match students’ age, experiences, and interests; other possible materials and equipment: laptop, iPad or computer, touch screen, screen reader software, or accessible mouse or switch for e-texts</p>
<p><i>Shared writing connection (5 minutes):</i> Students co-construct brief shared text with high teacher support related to the new book and reread their writing with support.</p>	<p>Today’s book, sentence strips, markers, scissors, interactive whiteboard, or writing frames or templates; laptop or desktop computer with talking word processor software, writing template, word bank, whole-word writing software, adapted keyboard or touch screen, or printer</p>

Figure 7.6: Example of a structured intervention (Schnorr, 2011: Page 37)

To summarise: this section has recommended a number of teaching approaches to promote the development of phonological processing, visual processing and memory, which were found to be deficient in the poorer readers and spellers in the CP group. Many of these teaching approaches are used in mainstream schools while others are designed to be used for children in special schools. In general, these require a high level of resource with small group or one to one teaching, either as interventions or as parts of lessons. Although many of these approaches have not been formally evaluated, it would seem a positive strategy to ensure they are extensively employed with children with CP so that they have a secure base of component skills to enable reading, spelling and handwriting development.

### **7.5: Limitations of the study**

There are many limitations to any research project due to the finite resources that can be devoted to the investigation, and the limited time that children have to take part in research. This research is no exception so the focus is on two issues. Although the number of children in the study (fifteen) is comparable with other studies in the literature (Dorman, 1987; Card and Dodd, 2006; Dahlgren Sandberg, 2006; Larssen and Dahlgren Sandberg, 2008), it would have been advantageous to have been able to include more children, which would have increased the power of the statistical tests and increased confidence in the generalisation of the findings.

Another limitation of the research is that there is no comparison group due to the difficulties of finding children with similar cognitive abilities within the same age group. This is often the case for research in this field and several studies (such as Sabbadini et al, 2001; Card and Dodd, 2006) have illustrated the difficulties involved in finding suitable controls. The use of standardised tests helped to overcome this difficulty, and provided a useful set of tools to enable us to understand the specific literacy and cognitive difficulties of the children with CP.

### **7.6: Further research**

The findings of the studies in this thesis has built on previous knowledge of the literacy development of children with CP, both of those with communication difficulties (Card and Dodd, 2006; Dahlgren Sandberg, 2006; Larssen and Dahlgren Sandberg, 2008) and those with more typical communication abilities (Dorman, 1987). However, most of the studies of children with more developed communication abilities were completed over twenty years ago, and since then there have been medical and therapeutic advances.

Furthermore, it is notable that the vast majority of research on children with CP, and their literacy development, was completed outside of the United Kingdom (Sweden, Canada, Australia, and The Netherlands). This makes generalisation of findings to and from the UK difficult as Sweden and The Netherlands have different orthographic structures to their languages, while Sweden, Canada and Australia have different school starting ages and different literacy strategies which might affect comparisons between age groups (as seen in the study by Card and Dodd, 2006). Thus, there is a need for international research projects which can tie together findings about the development of literacy in children with CP across different languages and educational contexts.

This study looked at the literacy development of children from the age of over six, but it was clear that many of the children had problems with literacy that are expected to be mastered by children of a younger age. Further research concerning the phonological abilities of younger children with CP might be useful in identifying why or if the children are so much slower at gaining these basic skills, and to see whether there have been any gains because of changes to, and recommendations about, teaching practice. The government has introduced a phonics test (DfE, 2012) for children at the end of Year 1 (children would be aged 6 years typically), and it would be useful to incorporate this standardised test as a basis for research between typical children and those with CP. In addition, it would be extremely interesting to carry out a full-scale longitudinal study concerning the development of these children, and the levels of literacy that it has been possible to attain with specialist support.

There was speculation regarding the copying difficulties in the handwriting task, as to whether the children had motor problems, a visual or spatial perception problem, or problems with reconstructing symbols (Abercrombie, 1964). It might be useful to research



this using a digital writing tablet that could be used to measure the speed of writing in a copying task (such as used by Sumner, Connelly and Barnett, 2013) to see if the children had a slow overall writing speed, which would implicate that their difficulties were caused by motor control problems. Alternatively, the tablet could be used to assess where there were pauses in the writing, or 'bursts' of writing (Connelly, Dockrell, Walter and Critten, 2012), for example, one could tell if there were pauses while writing a single letter due to referencing that letter several times, or whether children could write several words without pausing, showing that their writing difficulties were not due to motor control or problems with reconstructing symbols. Please see Table A3.1 in Appendix 3 for a breakdown of the children's scoring in the handwriting task.

As many of the children had difficulties with handwriting (copying), it would be useful to try an intervention, or number of interventions, to teach specific handwriting skills to children with CP. This could have the construct of action research, or the use of the microgenetic method (Flynn, Pine and Lewis, 2006) whereby each child's specific difficulties would be individually targeted and addressed in a short period such as every day over a week.

## **7.7: Conclusion**

The purpose of this thesis was to investigate why many children with CP have difficulties with learning to read, spell and write, while some children with CP have typical literacy abilities. A number of studies were designed to find out if an opportunistic group of children with CP have problems with literacy and whether any delays with their literacy development were related to specific cognitive difficulties. The first part of this final chapter focused on the findings from a number of studies within the thesis which suggested that those children with CP who had reading and spelling difficulties, had

impairments in particular areas of cognitive development which may have led to delays in the development of their literacy skills.

There were a number of new findings from the studies:

- That many of the children had impaired literacy difficulties despite good communicative abilities;
- That there were links between visual sequential memory and the children's reading and spelling abilities;
- That there were relationships between working memory and literacy abilities;
- That, although there were links between the children's phonological abilities and reading and spelling, these were not as strong as those in children with dyslexia;
- That the children's problems with writing were not necessarily linked to their reading and spelling development.

This thesis has been written to provide a new perspective on the literacy development of children with CP, particularly those who are making good progress in other areas of the curriculum within a specialist school. The findings of a large number of literacy and cognitive tests of children's abilities has built on, and added to, previous knowledge.

Identification of the children's relative areas of strengths and weakness has contributed to our understanding of the literacy development in children with CP, and provided a basis for consideration of their complex teaching and learning needs.

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## **Appendix 1: Difficulties with motor control and handwriting in children with CP**

Many children with CP, according to their type of disability, will face challenges with handwriting due to problems with motor control. However there are additional factors which can give rise to difficulties that may affect children who have other cognitive or physical disorders such as DCD and ADHD, (Feder and Majnemer (2007)). The first consideration is that of posture and the need for good seating arrangements so that the body is correctly aligned and supported. Occupational therapists will often assess the need for interventions to help children with CP to attain a good seating position for working, such as the use of a writing slope, or a box beneath the child's feet to ensure stability.

The next consideration is in the use of writing tools and the positions of the fingers to hold them. Many children with CP have motor control difficulties with their fingers due to poor muscle control or a lack of sensitivity. There can be difficulties with holding pencils or pens due to tensions in the fingers, lack of mobility and flexibility, or due to lack of awareness or perception of the movements of hands and fingers. Stewart, Pratt and McFadyen (1997) report that lack of kinaesthesia – the perception of the body's movements, and proprioception – the perception of the body's positioning, will affect the child's awareness of how to write. Children need to be able to hold and release a writing tool voluntarily, and be able to perform even and smooth strokes. Lack of flexibility in the fingers, hands and wrists can affect the ability of a child to change the direction of a pen stroke, replicate a particular angle of a letter or number, or increase or decrease the size of the figures.

These particular disorders affecting the legibility and speed of handwriting will have an influence on the amount of energy and concentration it takes to achieve a sustained piece of work. Children with CP take longer to write sentences or passages, so they are unable to

finish their work in lesson time or their answers or stories will be shortened as it is so difficult for them to maintain attention levels (Bumin and Tukul Kavak (2008). Bumin et al's study found that in copying tasks, the first two words were the most accurately written but that performance deteriorated after that, with inaccuracies and legibility featuring more highly as the copying was continued, and a decrease in the size of the letters. Bumin et al observed in their study that the children with CP had difficulties with producing legible handwriting and said this was due to their problems with individual letter copying. They suggest that "*...motor-control problems, along with visual perception and visual-motor-organization difficulties*" caused problems with the letters being the same size, and the letters or words not being placed within the guidelines on the page, e.g. because the lines were too narrow.



## **Appendix 2: Possible causes of cerebral palsy**

### **Hereditary:**

Static – familial athetosis, familial paraplegia, familial tremor

Progressive – demyelinating diseases of viral or undetermined origin (chromosomal breakages are rare in cerebral palsy, as are disorders of metabolism)

### **Congenital (acquired in utero)**

Infectious rubella, toxoplasmosis, cytomegalic inclusions, herpes simplex, and other viral or infectious agents

Maternal anoxia, carbon monoxide poisoning, strangulation, anaemia, hypotension associated with spinal anaesthesia, placental infarcts, placenta abruption

Prenatal cerebral haemorrhage, maternal toxæmia, direct trauma, maternal bleeding, diathesis

Prenatal anoxia, twisting or kinking of the cord

Miscellaneous toxins, drugs

### **Perinatal (obstetrical)**

Mechanical anoxia – respiratory obstruction, narcotism due to over sedation with drugs, placenta previa or abruptio, hypotension associated with spinal anaesthesia, breech delivery with delay of the after-coming head

Trauma – haemorrhage associated with dystocia, disproportions and malpositions of labour, sudden pressure changes, precipitate delivery, caesarean delivery

Complications of birth – ‘small for date’ babies, prematurity, immaturity, dysmaturity, postmaturity, hyperbilirubinemia and isoimmunisation factors (kernicterus due to Rh factor, ABO incompatibility), haemolytic disorders, ‘respiratory distress’ disorders, syphilis, meningitis and other infections, drug addiction reactions, hypoglycaemic reactions, hypocalcaemic reactions

### **Postnatal-Infancy**

Trauma (subdural haematoma, skull fracture, cerebral contusion)

Infections (meningitis, encephalitis, brain abscess)

Vascular accidents (congenital cerebral aneurism, thrombosis, embolism, hypertensive encephalopathy, sudden pressure changes)

Toxins (lead, arsenic, coal tar derivatives)

Anoxia (carbon monoxide poisoning, strangulation, high-altitude and deep-pressure anoxia, hypoglycaemia)

Neoplastic and late neurodevelopmental defects (tumour, cyst, progressive hydrocephalus).

From Kolb and Wishaw (1996) Pg 527 (original source: Denhoff, 1976)

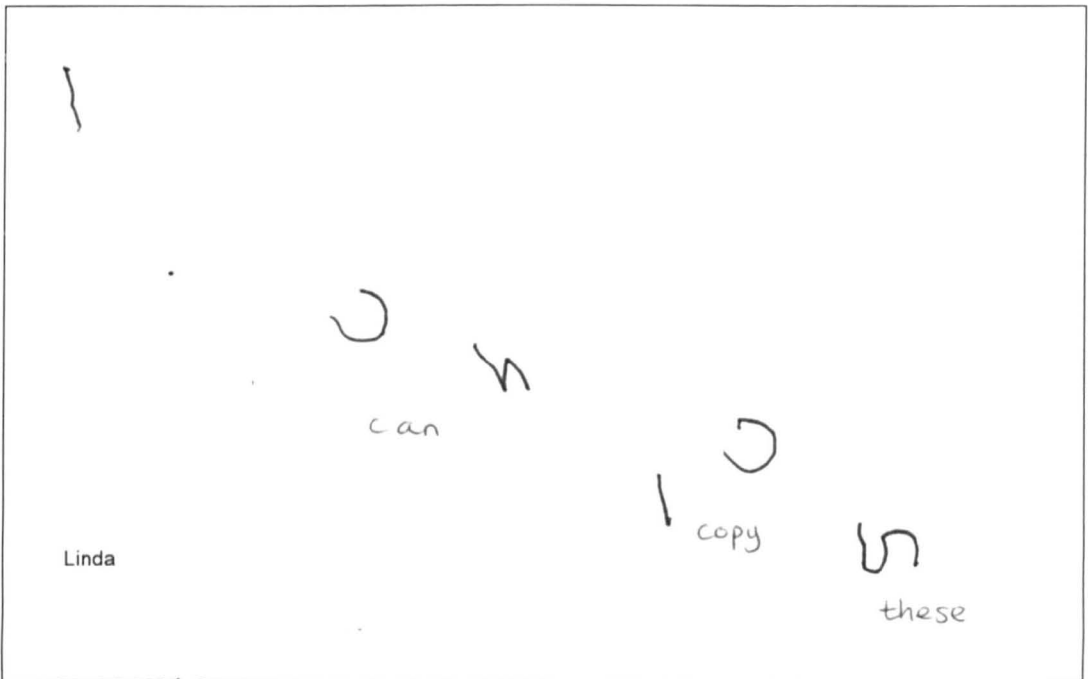
**Appendix 3: Handwriting Samples from the DST (Fawcett and Nicolson, 2004)**

“I can copy these words in a minute. I am fast as well as neat.” (Pg 28)

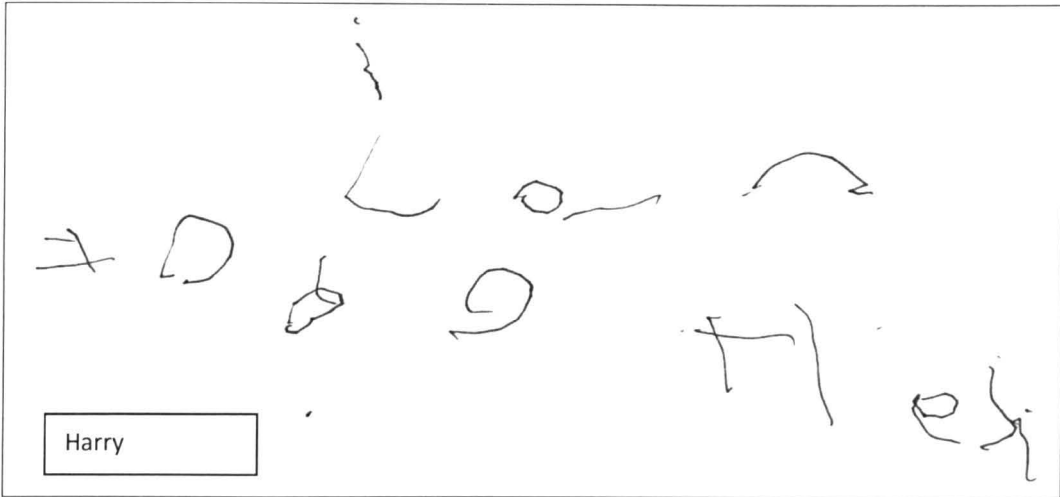
For children aged 6.6 – 7.5 years



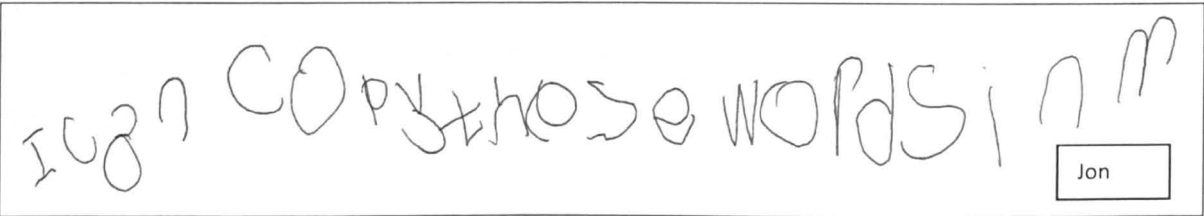
Ian: Right handed: 3 words; Writing quality -3: Score = 1<sup>st</sup> centile



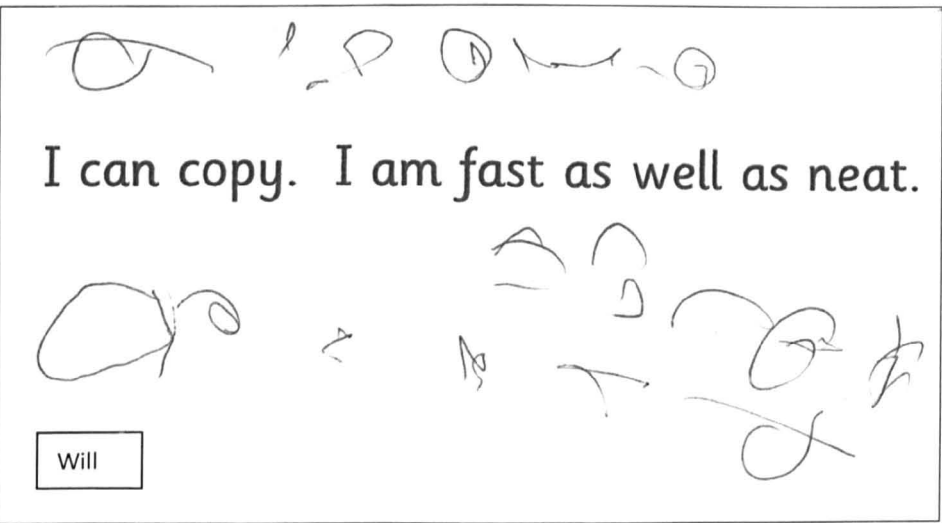
Linda: Right handed: 1 word: 14 errors; writing -3: Score = 1<sup>st</sup> centile



Harry: Right handed: 4 words; writing quality -1: Score = 5<sup>th</sup> centile



Jon: Right handed; 6 words; writing quality -1: Score = 3<sup>rd</sup> centile



Will: Left handed; 0 words; writing quality -3: score = 1<sup>st</sup> centile

"I am copying a short passage. I have one minute to write as much as I can, as well as I can." (Pg 28)

For children aged 8.6 – 10.5 years

I am copying a short passage

Joe

Joe: left handed; 5 words; writing quality -1: Score = 6<sup>th</sup> centile

I am copying a short passage

Lee

Lee: Right handed; 3 words; error -1; writing quality -1: Score = 1<sup>st</sup> centile

I am copying a short passage I have one minute to

Beth

Beth: 11 words; writing quality -1; punctuation -2: Score = 10<sup>th</sup> centile

I am copying a short passage

Cleo

Cleo: 6 words; writing quality -1: Score = 6<sup>th</sup> centile

I am copying a short passage

Garth

Garth: left handed; 5 words; writing quality -1; punctuation -2: Score = 2<sup>nd</sup> centile

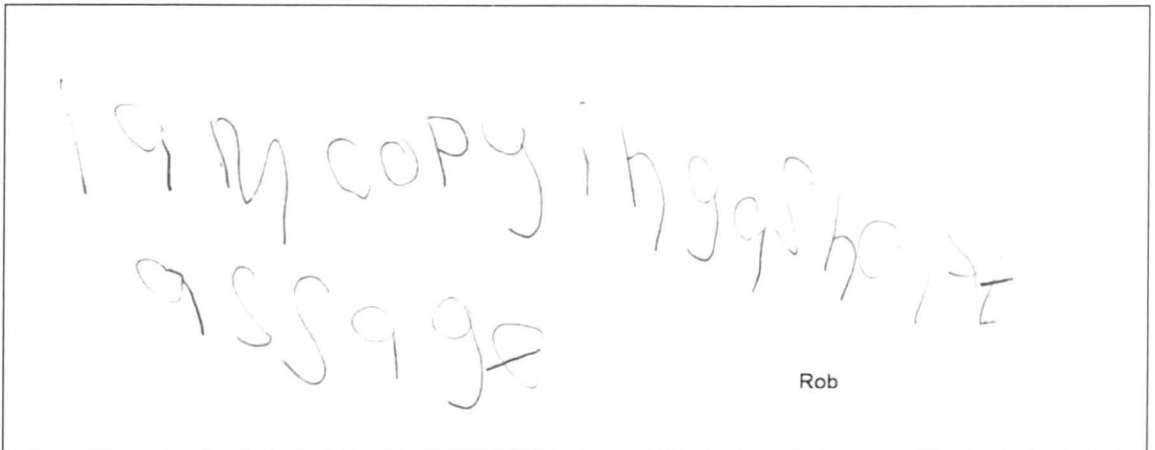
I am copying a short passage

Lewis

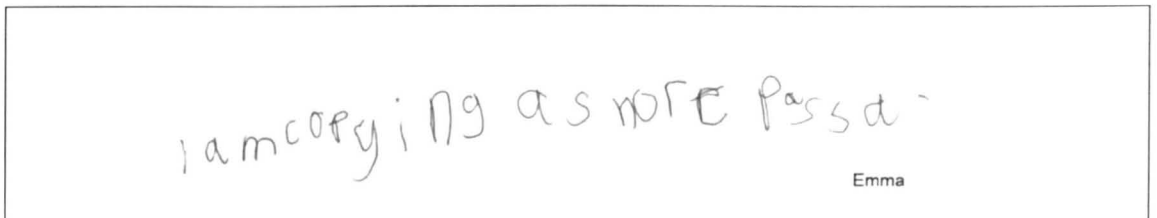
Lewis: right handed; 4 words; errors -2; writing quality -3; punctuation -2: Score = 1<sup>st</sup> centile

"I am copying a short passage to check my speed of writing. I have one minute to finish as much as I can. I should work quickly but accurately, so that my handwriting can be read." (Pg 28)

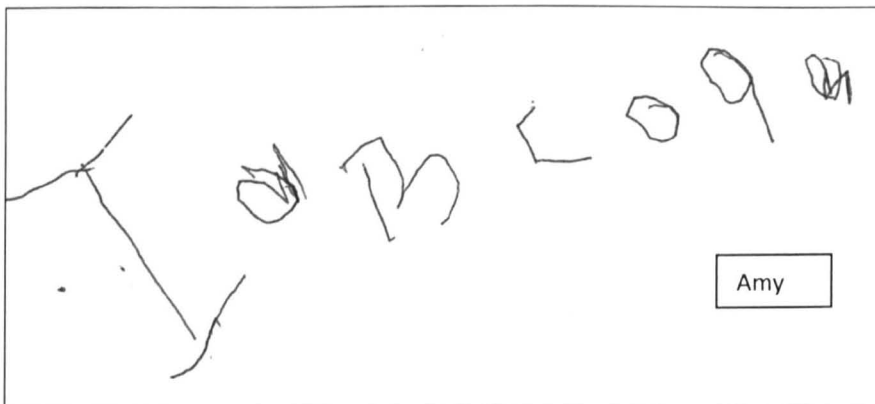
For children aged 10.6 – 11.5 years



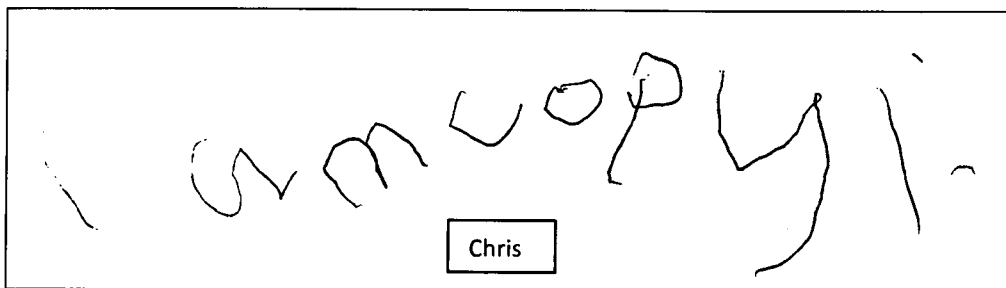
Rob: left handed; writing quality -1; punctuation -2: Score = 3<sup>rd</sup> centile



Emma: right handed; writing quality -1; punctuation -2: Score = 1<sup>st</sup> centile



Amy: left handed; writing quality -1; Score = 1<sup>st</sup> centile



Chris: right handed; 2 words; writing quality -1: Score = 1<sup>st</sup> centile

Table A3.1: Scoring the handwriting task

Name	Words completed	Correctly form individual letters	Legible writing	Capital letters	Spaces	Pauses to reference	P Scales or NC
Ian	3/22	no	no	no	0	Every letter	P5
Lewis	4/22	no	no	no	0	Every letter 2/3 times	P5
Beth	11/22	yes	yes	yes	5	Every few words	Level 2+
Garth	5/22	yes	yes	yes	0	Every letter	1C
Joe	5/22	yes	yes	yes	all	Simple words once	Level 2+
Harry	4/15	yes	yes	yes	all	Every letter 2/3 times	P8
Emma	5/36	yes	yes	yes	0	Every 2 or 3 letters	1B
Cleo	5/22	yes	yes	yes	all	Simple words once	1A
Linda	4/15	no	no	no	all	Every letter 2/3 times	P7
Amy	2/22	some	some	Yes	0	Every letter	P8
Chris	2/22	yes	yes	yes	1	Every letter	P8
Rob	6/36	yes	yes	yes	0	Every letter	1B
Lee	3/22	yes	no	yes	0	Every letter 2/3 times	P8
Jon	6/15	yes	yes	yes	0	Every letter	1C
Will	0/22	no	no	no	0	Every letter	P5

The majority of the children are aged over 8 years, and should be working at a National Curriculum level of between Level 2 and 3, while the older ones, Emma and Rob, should be

working at Level 4. Children who are working at P scale levels: Ian, Lewis, Harry, Linda, Amy, Chris, Lee and Will, are still in the very early alphabetic phases of writing development (Steffler and Critten, 2007). There are only two children who are working close to their expected level of attainment in writing styles (Beth and Joe).

The main difficulty for the children was the number of words copied within the minute time period. None of the children completed the passage within the time. Beth wrote the most words (eleven) while Will wrote the fewest (none legible). It might be said that the children wrote slowly because of poor motor control but that might not necessarily be the full explanation. Looking at the number of spelling or omission errors, ten of the fifteen children copied the words correctly with no spelling errors. Linda and Will scored the majority of errors because they used only approximations of letters. Lewis and Lee had two errors each because they omitted letters.

Looking at the scores for writing style, the majority of the children – again ten of the fifteen - had one penalty point each. This was because their writing styles were assessed as immature in that each letter was demarcated correctly but the writing was not joined up in the way normally expected of any child above 7-8 years. Ian, Lewis, Linda, Lee and Will scored -3 as their words would have been illegible if there was no transcript. Individual letters could be identified but the whole of the text was unreadable as the letters were poorly drawn. Punctuation errors scored the most penalty points and, apart from one omitted full-stop from Beth, all the errors were caused by missing spaces between the words.



## **Appendix 4: Standard Assessment Tests (SATs) Guide**

### **'End of key stage' tests**

Your child will take national tests at the end of Key Stage 2. The tests are intended to show if your child is working at, above or below the target level for their age.

This helps the school to make plans for their future learning. It also allows schools to see whether they are teaching effectively by comparing their pupils' performance to national results.

### **Key Stage 1 teacher assessments, tasks and tests**

Teacher assessment for seven year olds covers:

- reading
- writing
- speaking and listening
- maths
- science

These assessments take account of how your child performed in Key Stage 1 tasks and tests for seven year olds. The tasks and tests cover:

- reading
- writing (including handwriting and spelling)
- maths

The tasks and tests can be taken at a time the school chooses. They last for less than three hours altogether. The results are not reported separately but are used to help the teacher assess your child's work. By the age of seven, most children are expected to achieve level 2. The teacher assessment is moderated by your local authority. This is to make sure teachers make consistent assessments of children's work.

### **Key Stage 2 tests and teacher assessments**

Key Stage 2 tests for 11 year olds cover:

- English - reading, writing (including handwriting) and spelling
- maths - including mental arithmetic
- science

These tests are taken on set days in mid-May and are designed to test pupils' knowledge and understanding. Depending on which tests children sit, the tests last between four and seven and a half hours. The teacher assessment covers:

- English
- maths
- science

By the age of 11, most children are expected to achieve level 4.

Taken from:

[http://www.direct.gov.uk/en/Parents/Schoolslearninganddevelopment/ExamsTestsAndTheCurriculum/DG\\_10013041](http://www.direct.gov.uk/en/Parents/Schoolslearninganddevelopment/ExamsTestsAndTheCurriculum/DG_10013041) (Accessed 23rd August 2012)

## Appendix 5: Correlations between cognitive test scores

### Relationships between the cognitive tests and visual measures

Table A5.1: Correlations above 0.4 between the visual perception tests and the other cognitive measures

Correlations above 0.4 of Cognitive tests and Visual tests								
	Visual memory	V sequent memory	Spatial relation	Visual discrim	Form const	Figure ground	Figure closure	Visual percep
<b>Phon Processing</b>								
Phon segment		.626*	.644**	.522*				0.441
Verbal fluency		0.434						
RAN	.653**	.524*	.556*	.616*				.538*
<b>Abilities</b>								
Raven's matrices	.569*	0.418	.561*	.597*	.753**	.517*	0.446	.728**
CCC2								
Receptive vocab							0.426	
Mill Hill semantic							0.504	
Semantic fluency							0.486	0.437
<b>Working memory</b>								
<b>Verbal Recall</b>								
Digit recall		0.477	0.482				0.4	0.504
Word list recall		.515*	0.428					0.482
Nonword list re		.659**	0.438					0.493
<b>Visual recall</b>								
Block recall								
Mazes memory	0.453		.557*	.662**		0.449		.673**
<b>ELWM</b>								
Listening recall	.709**	.596*	.807**	.766**				.573*
Word list match	0.482	.731**	.672**	.631*	0.405			.645**
Backward digit								

\*\* Correlation is significant at the 0.01 level (2 tailed); \* Correlation is significant at the 0.05 level (2 tailed)

Looking at Table A5.1, the correlations between the visual tests and the other cognitive tests suggest that:

- There are a number of significant and highly significant correlations between four of the visual tests (visual memory; visual sequential memory; spatial relationships; and visual discrimination) and visual perception with many of the other cognitive tests.
- Two of the cognitive tests which included visual components such as Raven's matrices and RAN were significantly correlated with those four visual tests and visual perception as a whole. However, the results of the receptive vocabulary test, which included pictures, had weak correlations with these four visual tests
- There were three significant correlations between the phonological segmentation test (a purely verbal test) and the visual tests.
- There are significant and highly significant correlations between the listening recall and the word list matching tests of the ELWM, and the four visual tests and the total visual perception tests.
- There are moderate relationships of above 0.4 between the vocabulary tests measuring ability (receptive vocabulary, Mill Hill semantic and semantic fluency) and digit recall (PSTM) with the Figure closure test.
- The three verbal recall tests of PSTM had moderate, but not significant, correlations of above .4 with the visual sequential memory test and the spatial relationships test (both of which were correlated with the reading and spelling tests).

### **Discussion**

There were many significant and highly significant correlations between the Raven's Matrices test and the visual perception tests. It has been suggested in the main text that the children's poor results in the Raven's test were due to their visual difficulties, and the associations between the two tests show that may be the case (Pueyo et al, 2008).

However, both sets of results contained low percentile scores, including a number of zero scores on the visual tests, so these results should be approached with caution.

A number of the children had difficulties with the RAN test including some of the better readers, so there were moderate non-significant correlations between RAN and the reading and spelling tests ( $\rho$  not above 0.45). It was speculated that this might be because some of the children were hesitant in their speech, however, looking at the table above, it is possible that the children's problems with RAN may have been due to their difficulties with visual perception. There were five significant correlations between the visual tests and RAN. Interestingly, the three visual tests that did not correspond to the RAN test – figure conservation, ground and closure were also the visual tests that had weak relationships with the literacy tests, indeed, many had negative values.

Looking at the four verbal working memory test scores, visual spatial relations and visual sequential memory had the most significant correlations between the percentile scores. This corresponded with the comparisons between the reading and spelling percentile scores and the two visual tests in the previous chapter. The word matching test also had moderate to strong correlations, of which several were significant, with all the visual tests. This again suggests that there was a visual aspect to the processes involved in this test despite it being part of the phonological group of tests.

The two working memory tests associated with the visual spatial sketchpad were divided in their relationships with the other tests. The block recall test had weak correlations with the visual tests, while the mazes memory test had stronger correlations with many of the visual tests with significant correlations with the scores of visual discrimination, spatial relationships and visual perception as a whole.

Similarly the results of the tests of the central executive were divided in their correlations. The backward digit test showed weak correlations with the visual tests. However, while the list recall test had a number of weak correlations with the figure conservation, figure ground and figure closure percentile scores, it had highly significant correlations with the other five visual tests.

## Appendix 6 : Educational Policies and the teaching of literacy

The context of current teaching is influenced by educational policy which has long emphasised the need for the teaching of literacy to be underpinned by psychological research (Rose, 2006; Torgerson, Brooks and Hall, 2006 ) and modifications to theories have often led to changes in the way literacy is taught in schools (Stone, 2004). Reports that many children are failing to read and write to the accepted standard by the end of Key Stage 2 (National Literacy Trust Report, Clark and Foster, 2005), have influenced pedagogy, and educators in England and Wales are expected to teach children to read and spell using synthetic phonics (Rose, 2006). There has also been some governmental discouragement (DFE, 2011a) of the utilisation of word recognition, analogy, context and other strategies previously suggested in the provision of the National Literacy Strategy (DfES, 1998). A screening check for Year 1 infants is being used to test children's phonological processing abilities (DFE, 2011b) in order to give extra help to children who are assessed as being delayed in their literacy development.

Constant changes in strategy and the implementation of new initiatives, such as new national curriculums when there are changes in government, leave teachers bewildered and confused when many are sure that a single theory or method of teaching is not always applicable because children have different learning styles (Hulme and Snowling, 2009). A precisely structured programme of instruction such as in 'Letters and Sounds' (DCFS, 2007) delivered to a strict calendar, e.g. the learning of five or seven phonemes a week, may not suit some children and can result in the beginnings of reading failure or '*points of discouragement*' (Byrne, 2005, Pg 106). Byrne argued that learning is a two-way process between the teacher and the student, in which some aspects of the student's ability, such

as vocabulary development, and genetic influences can affect the outcome of any programme of study delivered by a teacher.

Similarly, Rose (2006) has acknowledged that some aspects of a student's contribution in lessons may be inadequate or impaired and so affect the outcomes of the programmes of study. He comments that some students

*"...have neuro-developmental disorders and other special educational needs that may present formidable obstacles to learning to read and write" (Pg 5).*

One of the most common reasons for difficulties with learning to read may be connected to the level of ability or innate intelligence of the student. If a child has difficulties with all types of learning this is going to affect how quickly literacy skills may develop. In studies such as Rutter and Yule, 1975, and Stanovich and Siegel, 1994, the findings suggest that while children with low intelligence are delayed in literacy acquisition (Hulme and Snowling, 2008) they do develop along typical pathways. However, children with physical impairments may need to have more specific educational provision to meet their needs (DFES, 2004).

Teachers are encouraged to implement new literacy strategies in mainstream schools, while teachers in special schools are expected to modify these strategies so that the children are able to access teaching and learning. Children in special schools currently have Statements of Special Educational Need, which are legal documents that outline their particular educational or social difficulties, and IEPs (Individual Education Plans) which specify particular areas of need which are to be developed (DfES, 2004). The presence of smaller classes and larger staff-pupil ratios means that teachers in special schools are considered to be able to tailor teaching approaches more easily to suit the learning needs of their pupils.



Whichever educational establishment a child with SEN attends, teachers have to make decisions regarding the content and mode of provision of lessons. These decisions are made after an assessment of the child's strengths and weaknesses in specific subject areas (Hulme and Snowling, 2009).